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Project 273

IMPINGEMENT, ENTRAINMENT
AND NET DETERRENT STUDIES
AT THE J.R. WHITING PLANT
DURING 1979

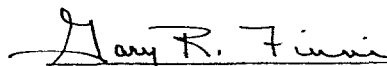
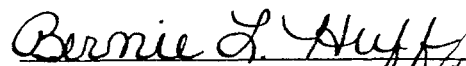
FINAL

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1.0 SUMMARY

The J.R. Whiting Plant, owned and operated by Consumers Power Company, is located in Erie, Michigan on the western shore of Lake Erie. The plant uses lake water from North Maumee Bay as a condenser coolant and discharges water back into Lake Erie. A nine month study (April through December 1979) was conducted to determine the number and types of organisms impinged on the plant's travelling screens and to determine the extent of larval fish and fish egg entrainment in the cooling water.

During this study, 408,581 fish ($9.623/1000 \text{ m}^3$) representing 43 species and two hybrids (15 families) were impinged on the plant's travelling screens. The five most abundant species impinged were gizzard shad (70.60% of the total), emerald shiner (20.20%), spottail shiner (2.70%), yellow perch (2.67%) and goldfish (1.42%), which accounted for 97.59% of all impingement.

From April through December 1979 it was estimated that 17,378,518 fish (110,358 kg) were impinged. Estimated impingement was highest in November (14,857,042; 89,595 kg) and accounted for 85.5 percent of the total numerical estimate. During November, gizzard shad accounted for over 99 percent of the estimate (both numbers and biomass).

During the seven month entrainment (ichthyoplankton) study, 18 taxa representing nine families were collected in drift nets set in the discharge. Numerically, the five most abundant taxa collected during this study were gizzard shad (91.0% of the total), freshwater drum (5.4%), carp or goldfish (1.5%), white bass (0.7%), and emerald shiner (0.6%).

It was estimated that 629,369,381 larvae and 553,620,137 eggs were entrained by the Plant during 1979. Estimated larval and egg entrainment was highest in June (473,807,630) and July (452,774,160), respectively. Gizzard shad, freshwater drum, carp or goldfish, and emerald shiner accounted for approximately 98 percent of the total entrainment estimate.

Two tests of deterrent nets across the intake were conducted during September and October. The first test, conducted from September 10 through October 12, appeared to be effective in reducing impingement; the second test, conducted from October 19 through 29, was ineffective. The apparent ineffectiveness resulted from difficulties in keeping the net's float line at the surface and the bottom sealed when debris and mud accumulated on the net. The added weight and resistance resulting from the accumulation of debris and mud submerged the net's float line, raised the anchor line, and ultimately reduced the effectiveness of the barrier.

2.0 INTRODUCTION

As a result of the intake of cooling water by power plants, fish and other aquatic organisms are entrained and either pass through the cooling condensers or are impinged on the power plant's travelling screens. Fish impingement and entrainment studies were first conducted at the J.R. Whiting Plant during 1974 through 1975 (Consumers Power Company 1976). The results of that study were not accepted by the Michigan Department of Natural Resources (MDNR) as demonstration of an intake of best available technology to minimize adverse impact to the aquatic environment. To reduce impingement and to resolve discrepancies from results of several ichthyoplankton studies in that area, Consumers Power Company installed and tested a new design of an electrical fish deterrent, and conducted fish larvae assessments in Maumee Bay and of entrained larvae. The electrical deterrent was not successful in reducing fish impingement, but the fish larvae studies demonstrated that larval concentrations were much higher in Maumee Bay, but only a small percentage were entrained by the J.R. Whiting Plant. A Production Foregone analysis indicated that entrainment of larvae and impingement of adults and juveniles would not result in an adverse impact to the aquatic ecosystem of western Lake Erie.

The objectives of this study were to (1) monitor the impingement of fish on the J.R. Whiting Plant's travelling screens and to estimate the number per species impinged during the period of study, (2) monitor the entrainment of fish eggs and fish larvae through the J.R. Whiting Plant's cooling system and estimate the number per taxon entrained during the study period, and (3) determine the effectiveness of a deterrent net in reducing the number of juvenile and adult fish impinged.

This report summarizes the results of the impingement monitoring that was initiated in April and conducted through December 1979, the results of entrainment monitoring that was initiated in April and conducted through October 1979, and the results of the deterrent net study that was conducted during September and October 1979. The remainder of this report is organized into the following subsections: a description of the plant and study area; the methods; the results of the impingement, entrainment, and deterrent net studies, including a comparison of the 1979 results of impingement and

entrainment with 1978's results; and literature cited. This study represents a continuation of the fish impingement and entrainment assessment and the initiation of a fish deterrent net program to reduce impingement during peak run periods.

3.0 STUDY AREA

3.1 Plant Description

The J.R. Whiting Plant is a coal-fired electric generating station owned and operated by Consumers Power Company. The plant is located in Erie, Michigan at the northern end of Maumee Bay (Figure 3-1).

The Whiting Plant has three coal-fired units; Units 1 and 2 each have a gross capacity of 105 megawatts (MW), and Unit 3 has a gross capacity of 133 MW (Consumers Power Company 1976). Units 1 and 2 began production in 1952 and Unit 3 began production in 1953.

The plant uses water as a once-through condenser coolant. Water is drawn through an intake located at the extreme northern end of a channel linking North Maumee Bay with the plant. Two sets of trash racks remove large debris; three vertical traveling screens (3/8-inch wire mesh) prevent fish and smaller debris from entering.

Each unit has two circulating water pumps for condenser cooling purposes. Unit 1 and 2's pumps are each rated at 30,000 gallons per minute (gpm) at a 30-foot head. The pumps for Unit 3 are rated at 47,000 gpm at a 25-foot head. The combined rate maximum flow is 214,000 gpm. Time of condenser passage has been calculated to range from 23.1 minutes (all pumps and units operating) to 128.5 minutes (1 unit and 1 pump operating). Heated water is discharged directly to Lake Erie.

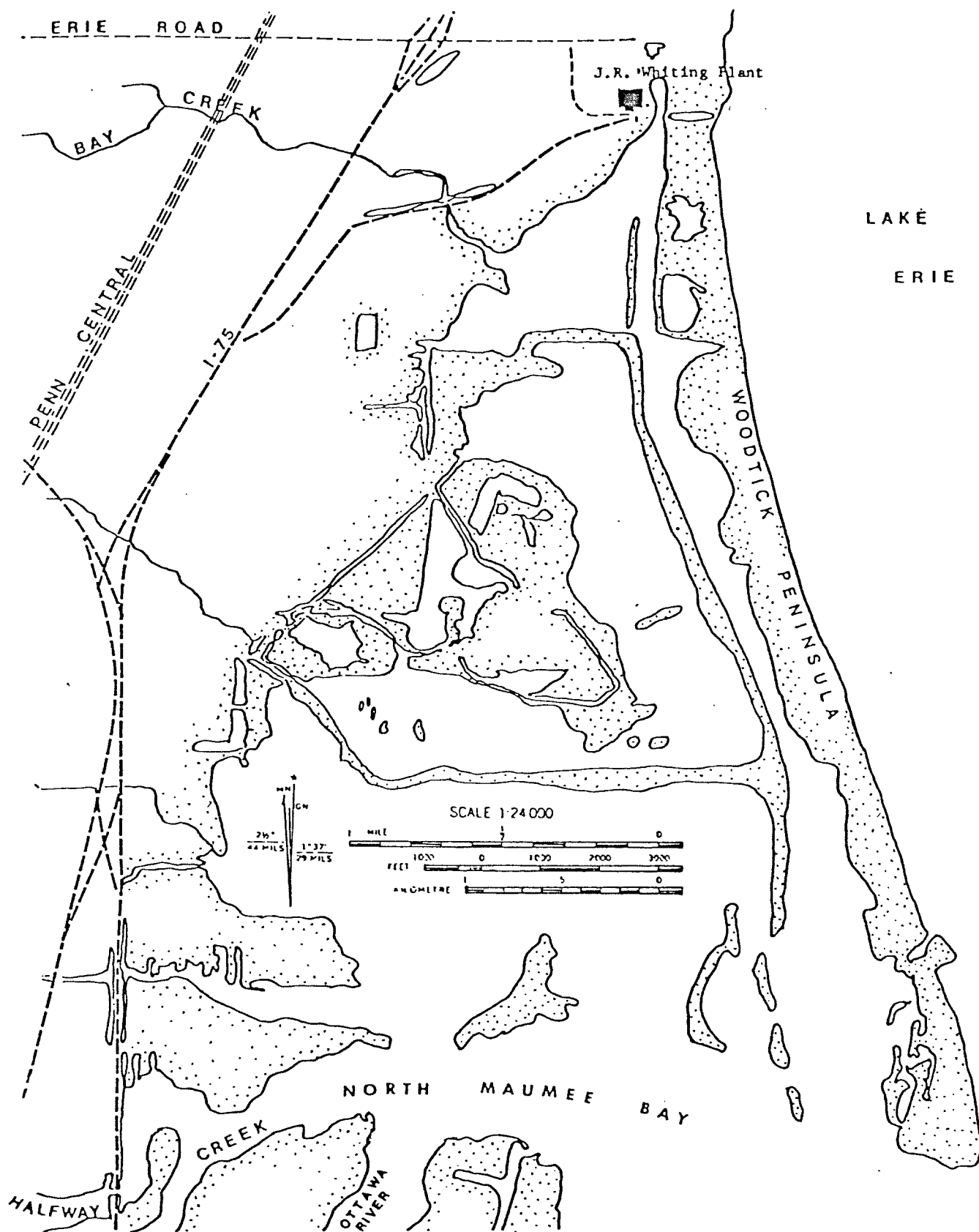


FIGURE 3-1. LOCATION OF THE J.R. WHITING PLANT ALONG THE SHORE OF NORTH MAUMEE BAY, ERIE, MICHIGAN.

4.0 METHODS

4.1 Impingement

4.1.1 Field Collection

The monitoring of fish impinged on the travelling screens at the J.R. Whiting Plant was conducted from April through December 1979; sampling took place on 76 dates during this time period (Table 4-1).

Prior to initiating an impingement sampling, the travelling screens were backwashed by Consumers Power Company personnel to remove fish and debris. After a 24-hour impingement period, the travelling screens were again backwashed and the impinged fish were collected in a three-eighths inch mesh metal basket placed in the backwash trough adjacent to the screens. During periods of heavy fish impingement, sampling periods were shortened.

Fish removed from the screens were either processed at the Plant or were preserved in a ten percent formalin solution and transported in pre-labelled plastic bags to WAPORA's Lansing, Michigan office for laboratory processing. Data recorded during each sampling included the weather conditions, intake and discharge water temperature, dissolved oxygen, and duration of the impingement sampling period; prevailing weather conditions and water temperatures are reported in Appendix Table A-2.

4.1.2 Fish Processing

Adult fish were identified to species using keys found in Eddy (1957), Hubbs and Lagler (1964), and Scott and Crossman (1973). From each week's impingement, a subsample of 25 individuals per species (if that many were present) was selected and each individual was measured (total length in mm) and weighted (grams); the remaining individuals, if more than 25 were collected, were counted and weighed en masse. An attempt was made to select specimens that were representative of the size range of the individuals collected.

TABLE 4-1. THE SAMPLING DATES DURING 1979 ON WHICH IMPINGED FISH WERE COLLECTED FROM THE TRAVELLING SCREENS AT THE J.R. WHITING PLANT.

Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
02	01	01	02	09	06	02	06	04
03	02	06	13	15	10	05	08	06
10	03	07	19	23	14	09	13	10
11	09	12	25	30	18	11	15	11
12	10	14	31		21	15	19	12
13	16	20			25	18	21	18
14	18	21			27	23	27	20
16	23	27				25	30	27
17	30					31		28
18								
19								
20								
23								
24								
25								
26								
27								

4.1.3 Data Processing

The results of impingement sampling are reported as the actual number of individuals of each species impinged during each collection period (Appendix Table A-3); the mean length and mean weight for each species is reported as well. Daily and monthly impingement estimates refer to the number of fish estimated to have been impinged and is based upon the assumption that impingement rates during the 24-hour sampling periods were representative of actual impingement rates (WAPORA 1979).

Estimates for impingement were calculated using the following formulae:

$$I_d \text{ (daily impingement density)} = \frac{N \cdot IT}{V \cdot t}$$

$$\text{and: } I_{\text{cum}} \text{ (cumulative impingement density)} = \frac{\sum_{i=1}^n N \quad \sum_{i=1}^n IT}{\sum_{i=1}^n V \quad \sum_{i=1}^n t}$$

$$\text{and: } I_{\text{est}} \text{ (estimated impingement)} = \sum (I_d \cdot IV_{\text{est}})$$

where: $i = 1 \dots n$

N = number impinged during a monitoring period

V = intake volume for monitoring period (m^3)

IT = time associated with plant intake volume (hours)

t = time of impingement (hours)

IV_{est} = intake volume for time interval of the estimate (m^3)

IV_{est} is developed for a specific monitoring period (I_d) and equals the sum of the daily intake volumes for a time interval from a date halfway to the preceeding monitoring period (I_d) and to a date halfway to the succeeding monitoring period. Total daily condenser discharge volumes (MGD) were provided by Consumers Power Company for the April through December 1979 sampling period (Appendix Table A-2).

4.2 Entrainment

4.2.1 Field Sampling

The entrainment of fish eggs and fish larvae through the cooling water system of the J.R. Whiting Plant was monitored on 25 dates from April through October 1979; dates upon which sampling occurred are presented in Table 4-2.

On each date, four drift net samples of at least ten minutes duration each were collected from the discharge canal during the day and night. Day-time sampling was usually performed during the afternoon, whereas night-time sampling commenced 1.5 hours after sunset.

Ichthyoplankton was sampled using 0.5 meter mouth, simple conical, 351 μ mesh plankton nets fitted with a screw-on PVC collection bucket. Two nets, fastened within a metal bridle, were lowered by rope into the discharge canal; a ten pound (4.5 kilogram) depressor attached to the bridle kept the nets submerged and the net's mouth perpendicular to the flow. Water passing through the plankton net was metered with a calibrated Rigosha flowmeter (No. 773) centered within the net's mouth. The volume of water filtered during a ten minute sampling period was calculated by the following formulae:

$$V = \pi r^2 n k$$

where

V = Volume in m³

π = 3.1416

r = The radius of the net mouth

n = Number of meter units registered (determined by difference)

k = A flowmeter constant

After an appropriate sampling period, the nets were retrieved and the residue retained within was rinsed into the PVC bucket; the resultant concentrate was transferred from the bucket into a pre-labelled plastic quart jar containing sufficient formalin to result in a ten percent formalin solution. Rose Bengal stain was added to each sample to expedite ichthyoplankton sorting.

TABLE 4-2. THE DATES DURING 1979 ON WHICH ENTRAINMENT SAMPLES WERE COLLECTED FROM THE J.R. WHITING PLANT.

Apr	May	Jun	Jul	Aug	Sep	Oct
12*	02*	05*	02*	15*	13*	11*
23*	09*	06*	11*	22*	27*	25*
	16*	12*	18*			
	30*	14*	23 (N)			
		19*	24 (D)			
		20*	30*			
		26*				
		27*				

*Day and night combined

4.2.2 Laboratory Analysis

Each ichthyoplankton sample was analyzed as follows. A preserved sample was emptied onto an 0.125 millimeter mesh sieve, rinses with tap water, and then washed into a white enamel sorting tray. Fish eggs and fish larvae were removed from the accompanying debris, placed into pre-labelled 20 millileter scintillation vials, and preserved with five percent buffered formalin for storage. Prior to identification, samples containing more than 100 larvae were subsampled with a Folsom plankton splitter; no sample was split to less than 12.5 percent of the initial count,

All fish larvae were enumerated and identified to the lowest positive taxon. Additionally, the developmental stage of each larvae was noted and up to 50 individuals per developmental stage per taxon were measured (total length and body depth) to the nearest 0.1 millimeter. Larval fish were identified using the keys and descriptions published by Nelson and Cole 1975, Hogue, et al. 1976, Wang and Kernechan 1979, Mansuetti and Hardy 1967, Cooper 1977, and Snyder 1977. Fish eggs were enumerated, and up to 50 per sample were measured to the nearest 0.1 millimeter.

4.2.3 Data Analysis

The results of entrainment sampling are presented as the actual number entrained per taxon. The estimated number entrained is based upon the assumption that entrainment rates during the monitoring periods were representative of monthly and total entrainment rates (WAPORA 1979). Estimates were calculated by the following formulae:

$$E_{\text{cum}} \text{ (cumulative entrainment density)} = \frac{\sum N_r}{\sum V_r}$$

$$\text{and: } E_{\text{est}} \text{ (entrainment estimate)} = \sum_{i=1}^n (E_{\text{cum}} \cdot IV_{\text{est}})$$

where: $i = 1 \dots n$

r = replicate

N = Number of individuals

V = sample volume (m^3)

IV_{est} = intake volume for time interval of the estimate (m^3)

To calculate E_{est} it should be noted that E_{cum} is developed for a single monitoring period only and IV_{est} is the sum of the daily intake volumes from that monitoring period to a date halfway to the preceeding monitoring period and halfway to the succeeding monitoring period. Discharge volumes (MGD) for the J.R. Whiting Plant were provided by Consumers Power Company personnel.

4.3 Deterrent Net Study

In conjunction with ongoing impingement monitoring, the effectiveness of a barrier net as a deterrent to impingement of fish was assessed during two test periods: September 10 through October 12 and October 19 through October 29, 1979. During the September 10 through October 12 test period, a deterrent net was placed around pilings immediately in front of the trash rack. During the October 19 through October 29 period, a net was deployed across the inlet channel as described below. Impingement sampling frequency was increased to twice weekly from September through December 1979 to facilitate comparisons of impingement with the net in place and removed.

The duration of the test periods (when the net was in place) was long enough to allow for the initial impingement of fish that had reached the intake forebay prior to net deployment. Both net test periods were shortened due to net damage caused primarily by sediment build-up.

A 100 x 22 foot multifilament nylon net having three-eighths inch mesh were used as a barrier. The net was deployed from a 14 foot jon-boat across the inlet channel approximately 25 feet south of the causeway. When installed, the net extended from the west shoreline to the concrete sluiceway abutment on the east side, a distance of approximately 100 feet, and was secured to steel pilings in front of the intake trash rack. A diver checked the orientation of the net along the bottom of the channel and pressed the lead line into the bottom sediment to create a seal. Periodic inspection dives were also conducted while the net was in place.

The net was removed on October 12, 1979 after sediment collecting on the net drew the float line below the water surface and the lead line away

from the bottom. Upon removal, numerous holes were also found in the net; subsequently, a 30 foot by 20 foot, one-half inch mesh panel was added to the net, and the holes were patched. The net was reset on October 19 and removed on October 29, after similar damage was incurred.

5.0 RESULTS

5.1 Impingement

5.1.1 Results for 1979

Forty-three species of fish and two hybrids, representing 15 families, were identified from the 76 impingement samplings from the J. R. Whiting Plant between April and the end of December 1979 (Table 5-1, Appendix Table A-3). No species having an endangered or threatened status (Michigan Department of Natural Resources 1978) was identified from samples taken.

From April through December 1979, a total of 408,581 fish were collected which resulted in a cumulative density of $9.623/1000 \text{ m}^3$ (Table 5-2). On a numerical basis, five species--gizzard shad (70.60% of the total), emerald shiner (20.20%), yellow perch (2.67%), spottail shiner (2.70%), and freshwater drum (1.42%)--accounted for 97.59 percent of the individuals impinged; all other species had relative abundance values of less than one percent of the total number. On a biomass basis, 96.59% of the 5840 kg weight of fish impinged was accounted for by the following seven species: gizzard shad (54.70% of the total), yellow perch (18.03%), emerald shiner (11.14%), goldfish (5.65%), freshwater drum (2.64%), spottail shiner (2.44%), and white bass (1.99%). All other species had relative abundance values of less than one percent of the total biomass impinged (Table 5-2).

Monthly impingement rates reflected the seasonal abundance of various species and ranged from a low of $0.238/1000 \text{ m}^3$ in July to a high of $100.672/1000 \text{ m}^3$ in November 1979 (Tables 5-3 through 5-11, Figure 5-1). Seasonally, impingement rates were lowest during the summer (June through September) and highest during the late fall and early winter (October through December) (Figure 5-1).

Monthly impingement densities were dependent upon the seasonal abundance of the dominant species. Impingement densities for gizzard shad were lowest from May ($0.571/1000 \text{ m}^3$) through September 1979 ($0.302/1000 \text{ m}^3$),

increased dramatically during October ($18.884/1000 \text{ m}^3$), peaked in November ($99.431/1000 \text{ m}^3$), and decreased thereafter (December's impingement = $24.452/1000 \text{ m}^3$) (Figure 5-2). The extremely high impingement densities for gizzard shad were the result of an onshore movement by young-of-the-year individuals (mean length: 86 mm in November 1979).

Impingement densities for emerald shiner and spottail shiner were highest in April and May and decreased thereafter (Figures 5-3 and 5-4). For the emerald shiner, the impingement densities for April and May were $12.612/1000 \text{ m}^3$ and $1.012/1000 \text{ m}^3$, respectively; subsequently, impingement densities were less than $0.500/1000 \text{ m}^3$. Impingement densities for the spottail shiner for April and May were $1.188/1000 \text{ m}^3$ and $0.439/1000 \text{ m}^3$, respectively; impingement densities for the remainder of the year were less than $0.010/1000 \text{ m}^3$.

Goldfish impingement was highest during the spring and lowest during the summer and early fall (Figure 5-5); a slight increase in the impingement of goldfish was noticeable during November. During the monitoring period, impingement densities ranged from a September low of less than $0.001/1000 \text{ m}^3$ to a high of $0.452/1000 \text{ m}^3$ in April.

White bass impingement was less than $0.001/1000 \text{ m}^3$ through the spring and summer; impingement density increased during the fall and attained the monitoring period peak in November ($0.321/1000 \text{ m}^3$). Density decreased thereafter (Figure 5-6).

Freshwater drum impingement displayed a bimodal pattern with density peaks occurring in August and October (Figure 5-7). During the monitoring period, impingement densities ranged from a low of $0.019/1000 \text{ m}^3$ in December to an October high of $0.408/1000 \text{ m}^3$.

Maximum impingement of yellow perch, an important sport fish, occurred in April ($1.123/1000 \text{ m}^3$) (Figure 5-8); impingement of this species decreased through the spring and remained comparatively low through the summer, fall, and early winter. Densities for yellow perch ranged from

0.033/1000 m³ to 0.120/1000 m³ during summer, fall, and early winter.

From April through December 1979, a total of 17,378,518 fish (110,358 kg) was estimated to have been impinged (Tables 5-12 and 5-13). Estimated impingement was highest for gizzard shad (16,696,418; 102,116 kg) followed in decreasing numerical order by emerald shiner (463,256; 2,153 kg), spottail shiner (60,750; 447 kg), yellow perch (52,606; 3.020 kg), white bass (34,677; 501 kg), freshwater drum (30,865; 442 kg), and goldfish (20,585; 1,061 kg).

Estimated impingement was highest in November (14,857,042; 89,595 kg) and accounted for 85.5% of the estimated numerical impingement and 81.2% of the estimated impingement biomass. During November, gizzard shad was the dominant species impinged and accounted for 99.3% of the estimated impingement (numbers and biomass).

5.1.2 A Comparison Of Impingement Between 1978 and 1979

During the two years of sampling at the J. R. Whiting Plant, 47 species of fish, plus three hybrids, representing 16 families were collected. The 1978 study yielded 47 species plus three hybrids, as a result of a combined impingement and gill netting sampling effort (WAPORA 1979); during 1979, 43 species, plus two hybrids, were identified from impingement samples collected from the Plant. No species having an endangered or threatened species status (MDNR 1978) was collected either year.

Monthly impingement rates during both years of study reflected the seasonal abundance of various species, as shown in Figures 5-1 through 5-8. Seasonally, impingement rates were highest during late fall and early winter and lowest during the summer (Figure 5-1). Monthly impingement rates ranged from a high of 120.068/1000 m³ and 100.672/1000 m³ during 1978 and 1979, respectively, to a low of 0.533/1000 m³ and 0.238/1000 m³ during 1978 and 1979, respectively. During 1978, gizzard shad, emerald shiner, yellow perch, goldfish, and white bass comprised 93.52% of the total number of individuals impinged, whereas, 90.69% of the total biomass impinged was gizzard shad, yellow perch, goldfish, emerald shiner, and spottail shiner.

During 1979, 97.59% of the total number impinged were gizzard shad, emerald shiner, yellow perch, spottail shiner, or freshwater drum; gizzard shad, yellow perch, emerald shiner, goldfish, and freshwater drum comprised 92.16% of the biomass.

Estimated impingement for the March 1978 through February 1979 period was 7,720,829 fish (75,317 kg) and for the April through December 1979 period was 17,378,518 fish (110,358 kg). Estimated impingement was highest each year for gizzard shad, followed in decreasing numerical order by emerald shiner, spottail shiner, and yellow perch; other species having comparatively high estimated impingement rates during both periods were goldfish, white bass, and freshwater drum.

During the March 1978 through February 1979 monitoring period, estimated impingement was highest in November (4,718,129; 36,823 kg) and December (1,177,148; 13,279 kg) accounting for 75% of the estimated numerical impingement and 65% of the estimated impingement biomass. During these months gizzard shad was the dominant species impinged, accounting for over 95% of the estimated impingement (numbers and biomass).

From April through December 1979, estimated impingement was highest in November (14,857,042; 89,595 kg) and accounted for 85.5% of the estimated numerical impingement and 81.2% of the estimated impingement biomass. During November, gizzard shad was the dominant species impinged and accounted for 99.3% of the estimated impingement (numbers and biomass).

5.2 Entrainment

5.2.1 Results for 1979

Eighteen taxa representing nine families of fishes were collected in drift nets during day and night sampling at the J.R. Whiting Plant from April through October 1979 (Table 5-14, Appendix Table B-1 through B-3). The greatest number of taxa were identified from the family Cyprinidae (carp or goldfish, emerald shiner, spottail shiner, minnow species, bluntnose minnow, and minnow family); three taxa were identified in the family Percidae (yellow perch, logperch, and perch family); two taxa were identified in the

families Clupeidae (gizzard shad and herring family) and Centrarchidae (sunfishes and crappies); and, one taxon was identified from each of the following families: Catostomidae (carpsuckers or buffaloes), Ictaluridae (channel catfish), Percichthyidae (white bass), Sciaenidae (freshwater drum), and Osmeridae (rainbow smelt). No species listed as threatened or endangered (MDNR 1978) was collected.

Entrainment density varied seasonally and approximated the spawning/hatching times of the various taxa. Fish eggs were collected from April through August and displayed an annual cycle of an increase from April through July and a decrease thereafter. Egg density ranged from a low of 0/1000 m³ in September and October to a seasonal monthly high of 9,524/1000 m³ in July (Table 5-15, Figure 5-9, and Appendix Table B-3). Fish larvae were collected from May into October and displayed an annual cycle of an increase from none in April to a seasonal monthly high of 22,844/1000 m³ in June; density decreased thereafter (Table 5-15, Figure 5-10, and Appendix Table B-3). The number of larval taxa collected followed a similar trend, increasing from a low of zero in April to a maximum of 15 in June, then decreasing to one taxon in October.

Gizzard shad, the dominant ichthyoplankter, was present in drift net samples collected from May into October 1979. Seasonally, gizzard shad density increased from 0/1000 m³ in April to the June peak of 20,865/1000 m³ and decreased thereafter (Figure 5-11).

Carp-goldfish and all other Cyprinidae (excluding carp-goldfish) had similar seasonal patterns in density (Figures 5-12 and 5-13). Neither carp-goldfish or other Cyprinidae were collected in April, both were first collected in May, carp-goldfish reached the seasonal maxima in June (314/1000 m³), other Cyprinidae attained their seasonal maxima in July (157/1000 m³), and both decreased after having attained their respective maxima. Taxa included within the grouping other Cyprinidae were the emerald shiner, spottail shiner, bluntnose minnow, minnow family, and minnow species (*Pimephales* spp.).

The seasonal occurrence of yellow perch, white bass, and freshwater drum is presented in Figures 5-14 through 5-16. Yellow perch was collected only during May and June; its maximum monthly density was 80,618/1000 m³ and occurred in May. White bass was present from May through August and had a monthly maximum density of 145,842/1000 m³ in June. Freshwater drum were present from June through September; its peak density occurred in June 1,381,081/1000 m³.

Diurnal periodicity was apparent for both the entrainment of fish eggs and larvae. Night egg entrainment density exceeded day egg entrainment density on the majority of dates that eggs were collected. This was also true for larvae. Generally, more taxa were collected at night than during the day, 11 dates and 8 dates, respectively (Appendix Table B-1 and B-2).

Based upon drift net sampling from April through October 1979, 629,369,381 larvae and 553,620,137 eggs were estimated to have been entrained in the J.R. Whiting Plant's cooling water (Table 5-15). Estimated larval and egg entrainment was highest in June (473,807,630 and 65,747,278, respectively), July (84,699,885 and 452,774,160, respectively), and May (65,909,078 and 33,882,243, respectively). The taxa having the highest entrainment densities were gizzard shad (569,477,861), freshwater drum (32,762,696), carp-goldfish (7,372,177), emerald shiner (7,035,399), white bass (5,679,922), yellow perch (2,717,410), cyprinids (1,527,606), and sunfish (1,040,904).

5.2.2 A Comparison of Entrainment Between 1978 and 1979

During the two years of entrainment sampling at the J.R. Whiting Plant, 23 taxa of fish representing eight families were collected in entrainment samplings. The 1978 study yielded 17 taxa whereas 18 taxa were identified during 1979; eggs and unidentifiable larvae were collected each year as well. No taxon having an endangered or threatened species status (MDNR) was identified from entrainment samplings either year.

During both years, entrainment density varied seasonally and increased or decreased in response to the spawning/hatching times of various taxa. The seasonal occurrence of fish eggs and larvae for both years is

presented in Figures 5-9 and 5-10. Eggs were first collected in May during 1978 and in April during 1979 and were collected monthly thereafter through August during both years, however, no eggs were collected during September or October either year. Fish larvae trends were similar both years; larvae first occurred in ichthyoplankton samplings in May and were present throughout the spring, summer, and early fall (October) (Figure 5-10). The highest monthly larval and egg densities occurred during June and July, respectively, during both years.

The taxa that numerically dominated ichthyoplankton samplings at the J.R. Whiting Plant during 1978 and 1979 were gizzard shad, carp-goldfish, other Cyprinidae, yellow perch, white bass and freshwater drum. The temporal distribution and monthly density estimates for these taxa for each year are presented in Figures 5-11 through 5-16. The annual density maxima for each taxon occurred during the same month in 1978 and 1979.

A diurnal periodicity in the density of eggs and larvae entrained was apparent both years. Generally, night sampling had (1) higher egg densities, (2) higher larval densities, and (3) more taxa.

A comparison of the estimated entrainment at the J.R. Whiting Plant for 1978 and 1979 yielded the following contrasts:

Period of Sampling	1978	1979
	March through October	April through October
Total eggs	58,959,019	553,620,137
Total larvae	352,879,441	629,369,381
<u>Dominant taxa</u>		
Gizzard shad	325,006,681	569,447,861
Carp-goldfish	7,179,332	7,372,177
Freshwater drum	5,346,960	32,762,696
White bass	3,441,175	5,679,922
Yellow perch	1,729,360	2,717,410
Emerald shiner	1,880,459	7,035,399

Overall estimated egg and larvae entrainment during 1979 exceeded the estimate for 1978.

5.3 Deterrent Net

In conjunction with ongoing impingement monitoring, the effectiveness of a barrier net as a deterrent to impingement was assessed during two test periods: September 10 through October 12 and October 19 through October 29, 1979. Impingement sampling frequency was increased to twice weekly from September through December 1979 to facilitate comparisons of impingement with the net in place and removed.

A summary of impingement (number/1000 m³) prior to installation of the deterrent net, with the net in place, and after removal of the net for the two test periods is presented in Table 5-17. Daily impingement prior to installation of the net on September 10 was low; daily impingement continued to be low during September and during the first two impingement samplings in October. However, impingement increased during the last two sampling dates (October 9 and 11) of the first test period. The increase in impingement was probably due to an accumulation of debris and mud on the net; this added weight and resistance submerged the net's float line, raised the anchor line, and ultimately reduced the effectiveness of the barrier (Table 5-18). Prior to that time the net was apparently effective. When the net was removed on October 12, impingement increased on the succeeding dates, October 16 and 18.

During the second test period, the deterrent net was marginally effective, if at all. The apparent ineffectiveness of the net centered upon difficulties in keeping the float lines at the surface and the bottom sealed. Impingement increased in spite of the presence of the net (Table 5-17 and Figure 5-1).

Overall, the first test appeared to successfully reduce impingement, whereas, during the second test, the net was virtually ineffective. This relationship can be seen in Figure 5-1, a summary of the total cumulative impingement for the period of study.

TABLE 5-1. A LIST OF FISH COLLECTED FROM THE TRAVELLING SCREENS
AT THE J.R. WHITING PLANT FROM APRIL THROUGH DECEMBER
1979.

<u>Scientific Name</u>	<u>Common Name</u>
PETROMYZONTIDAE	Lampreys
<i>Ichthyomyzon unicuspis</i>	Silver lamprey
LEPISOSTEIDAE	Gars
<i>Lepisosteus osseus</i>	Longnose gar
CLUPEIDAE	Herrings
<i>Alosa pseudoharengus</i>	Alewife
<i>Dorosoma cepedianum</i>	Gizzard shad
SALMONIDAE	Trouts
<i>Oncorhynchus kisutch</i>	Coho salmon
<i>Oncorhynchus tshawytscha</i>	Chinook salmon
OSMERIDAE	Smelts
<i>Osmerus mordax</i>	Rainbow smelt
UMBRIDAE	Mudminnows
<i>Umbra limi</i>	Central mudminnow
ESOCIDAE	Pikes
<i>Esox lucius</i>	Northern pike
CYPRINIDAE	Minnows and Carps
<i>Carassius auratus</i>	Goldfish
<i>Cyprinus carpio</i>	Carp
<i>Hybopsis storeriana</i>	Silver chub
<i>Notemigonus chrysoleucas</i>	Golden shiner
<i>Notropis atherinoides</i>	Emerald shiner
<i>Notropis cornutus</i>	Common shiner
<i>Notropis hudsonius</i>	Spottail shiner
<i>Pimephales promelas</i>	Fathead minnow
<i>Semotilus atromaculatus</i>	Creek chub

Table 5-1 (continued)

<u>Scientific Name</u>	<u>Common Name</u>
CATOSTOMIDAE	Suckers
<i>Carpionodes cyprinus</i>	Quillback
<i>Catostomus commersoni</i>	White sucker
<i>Moxostoma macrolepidotum</i>	Shorthead redhorse
ICTALURIDAE	Freshwater catfishes
<i>Ictalurus melas</i>	Black bullhead
<i>Ictalurus natalis</i>	Yellow bullhead
<i>Ictalurus nebulosus</i>	Brown bullhead
<i>Ictalurus punctatus</i>	Channel catfish
<i>Noturus flavus</i>	Stonecat
<i>Noturus gyrinus</i>	Tadpole madtom
PERCOPSIDAE	Trout-perches
<i>Percopsis omiscomaycus</i>	Trout-perch
PERCICHTHYIDAE	Temperate basses
<i>Morone americana</i>	White perch
<i>Morone chrysops</i>	White bass
CENTRARCHIDAE	Sunfishes
<i>Ambloplites rupestris</i>	Rock bass
<i>Lepomis cyanellus</i>	Green sunfish
<i>Lepomis gibbosus</i>	Pumpkinseed
<i>Lepomis humilis</i>	Orangespotted sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Micropterus dolomieu</i>	Smallmouth bass
<i>Micropterus salmoides</i>	Largemouth bass
<i>Pomoxis annularis</i>	White crappie
<i>Pomoxis nigromaculatus</i>	Black crappie
PERCIDAE	Perches
<i>Perca flavescens</i>	Yellow perch
<i>Percina caprodes</i>	Logperch
<i>Stizostedion vitreum vitreum</i>	Walleye
SCIAENIDAE	Drums
<i>Aplodinotus grunniens</i>	Freshwater drum

Table 5-1 (continued)

Scientific NameCommon Name

Hybrids:

Carp x Goldfish

Green sunfish x Bluegill

TABLE 5-2. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, KG) DURING SEVENTY-SIX MONITORING PERIODS FROM APRIL THOROUGH DECEMBER 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT. (KG)	PCT. COMP. NO.	WT.	NUMBER MEASURED	MEAN TOTAL LENGTH (MM)	MEAN WEIGHT (GM)
SILVER LAHPREY	9	<.001	15	.910	<.01	.02	9	268	62
LONGNOSE GAR	1	<.001	2	.075	<.01	<.01	1	286	46
ALEWIFE	286	<.001	465	8.839	.07	.15	222	127	19
GIZZARD SHAD	288476	6.795	468620	3194.739	70.60	54.70	1399	127	44
COHO SALMON	17	<.001	28	15.923	<.01	.27	17	342	577
CHINOOK SALMON	3	<.001	5	.915	<.01	.02	3	236	188
RAINBOW SMELT	75	<.001	122	2.705	.02	.05	75	160	22
CENTRAL MUDMINNOW	2	<.001	3	.042	<.01	<.01	2	97	13
NORTHERN PIKE	5	<.001	8	1.795	<.01	.03	5	300	221
GOLDFISH	3503	.083	5691	329.729	.86	5.65	657	161	109
CARP	610	<.001	991	34.825	.15	.60	202	135	67
SILVER CHUB	18	<.001	29	.988	<.01	.02	18	154	34
GOLDEN SHINER	1	<.001	2	.008	<.01	<.01	1	76	5
EMERALD SHINER	82521	1.944	134053	650.560	20.20	11.14	756	85	4
COMMON SHINER	2	<.001	3	.084	<.01	<.01	2	131	26
SPOTTAIL SHINER	11051	.260	17952	142.809	2.70	2.44	664	90	7
FATHEAD MINNOW	4	<.001	6	.021	<.01	<.01	4	68	3
CREEK CHUB	7	<.001	11	.227	<.01	<.01	7	115	20
CARP X GOLDFISH	23	<.001	37	2.753	<.01	.05	23	119	74
QUILLBACK	30	<.001	49	8.488	<.01	.15	26	189	194
WHITE SUCKER	71	<.001	115	13.706	.02	.23	71	178	119
SHORTHEAD REDHORSE	14	<.001	23	.806	<.01	.01	14	128	35
BLACK BULLHEAD	103	<.001	167	5.983	<.01	.10	96	119	36
YELLOW BULLHEAD	1	<.001	2	.018	<.01	<.01	1	100	11
BROWN BULLHEAD	245	<.001	398	18.426	.06	.32	172	137	53
CHANNEL CATFISH	427	<.001	694	3.749	.10	.06	250	83	7
STONECAT	1	<.001	2	.028	<.01	<.01	1	128	17
TADPOLE MADTOM	44	<.001	71	.380	.01	<.01	44	75	5
TROUT-PERCH	527	<.001	856	6.829	.13	.12	216	93	8
WHITE PERCH	44	<.001	71	1.249	.01	.02	44	99	17
WHITE BASS	3055	<.001	4963	116.064	.75	1.99	1049	106	37
ROCK BASS	13	<.001	21	1.285	<.01	.02	13	125	61
GREEN SUNFISH	36	<.001	58	.218	<.01	<.01	19	58	4
PUMPKINSEED	60	<.001	97	4.734	.01	.08	60	124	49
ORANGESPOTTED SUNFISH	79	<.001	128	.791	.02	.01	71	63	7
BLUEGILL	15	<.001	24	.505	<.01	<.01	11	86	28
SMALLMOUTH BASS	2	<.001	3	.039	<.01	<.01	2	100	12
LARGEMOUTH BASS	1	<.001	2	.549	<.01	<.01	1	274	338
WHITE CRAPPIE	8	<.001	13	.359	<.01	<.01	8	97	28
BLACK CRAPPIE	43	<.001	70	6.191	.01	.11	38	129	95
GREEN X BLUEGILL	6	<.001	10	.037	<.01	<.01	2	69	8
YELLOW PERCH	10898	.257	17703	1053.025	2.67	18.03	1033	164	60
LOGPERCH	278	<.001	452	2.815	.07	.05	252	87	6
WALLEYE	177	<.001	288	52.777	.04	.90	177	245	184
FRESHWATER DRUM	5789	.136	9404	153.944	1.42	2.64	835	125	37

TOTAL	408581	9.623	663726	5840.942					
NUMBER OF SPECIES	45								
SAMPLING TIME (HRS)	1122.83								
INTAKE VOL. (CU.M)	68969989								

TABLE 5-3. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 17 MONITORING PERIODS IN APRIL 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT.(KG)	PCT. COMP. NO.	WT.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN WEIGHT(GM)
SILVER LAUREY	8	<.001	21	1.319	<.01	.03	8	281	64
GIZZARD SHAD	23583	3.908	60515	1316.993	19.88	32.38	133	150	51
COHO SALMON	9	<.001	23	20.036	<.01	.49	9	438	868
CHINOOK SALMON	1	<.001	3	1.309	<.01	.03	1	390	510
RAINBOW SLEET	46	<.001	118	2.856	.04	.07	46	160	24
CENTRAL MUMMINOW	2	<.001	5	.067	<.01	<.01	2	97	13
GOLDFISH	2730	.452	7005	316.110	2.30	7.77	154	168	125
CARP	509	.084	1306	29.733	.43	.73	101	121	36
EMERALD SHINER	76114	12.612	195311	956.421	64.17	23.52	125	91	5
COMMON SHINER	2	<.001	5	.133	<.01	<.01	2	131	26
SPOTTAIL SHINER	7169	1.188	18376	156.487	6.04	3.85	128	93	9
FATHEAD MINNOW	1	<.001	3	.013	<.01	<.01	1	71	5
CREEK CHUB	3	<.001	8	.241	<.01	<.01	3	136	31
CARP X GOLDFISH	13	<.001	33	.644	.01	.02	13	102	19
OUTILLACK	3	<.001	8	.190	<.01	<.01	3	118	25
WHITE SUCKER	46	<.001	118	19.173	.04	.47	46	201	162
SHORTHEAD REDHORSE	6	<.001	15	.262	<.01	<.01	6	106	17
BLACK BULLHEAD	96	<.001	246	8.003	.08	.20	89	116	33
YELLOW BULLHEAD	1	<.001	3	.028	<.01	<.01	1	100	11
BROWN BULLHEAD	171	.028	439	16.402	.14	.40	101	126	41
CHANNEL CATFISH	95	<.001	244	1.899	.08	.05	63	94	9
TADPOLE MADTOM	21	<.001	54	.259	.02	<.01	21	72	5
TROUT-PEACH	386	.064	990	8.314	.33	.20	105	94	10
WHITE PERCH	16	<.001	41	.677	.01	.02	16	103	17
WHITE BASS	479	.079	1229	49.073	.40	1.21	148	152	62
GREEN BASS	1	<.001	3	.005	<.01	<.01	1	42	2
GREEN SUNFISH	2	<.001	5	.044	<.01	<.01	2	77	9
PUMPKINSEED	21	<.001	54	3.092	.02	.08	21	128	57
ORANGESPOTTED SUNFISH	16	<.001	41	.113	.01	<.01	16	52	3
BLUEGILL	6	<.001	15	.362	<.01	<.01	6	87	24
WHITE CRAPPIE	3	<.001	8	.031	<.01	<.01	3	74	4
BLACK CRAPPIE	19	<.001	49	3.190	.02	.08	19	105	65
YELLOW PERCH	6780	1.123	17398	1115.251	5.72	27.42	151	168	69
LONGPERCH	69	<.001	177	1.224	.06	.03	69	90	7
WALLEYE	55	<.001	141	28.788	.05	.71	55	260	204
FRESHWATER DRUM	133	.022	341	8.101	.11	.20	93	118	28

TOTAL	118615	19.654	304371	4066.844
NUMBER OF SPECIES	36			
SAMPLING TIME (HRS)	159.00			
INTAKE VOL. (CU.M)	15486074			

TABLE 5-4. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 9 MONITORING PERIODS IN MAY 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT		PCT. COMP. NO.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN WEIGHT(GM)
			NO.	WT.(KG)				
SILVER LAHPREY	1	<.001	1	.048	<.01	1	170	46
ALEWIFE	4	<.001	6	.233	.03	4	180	40
GIZZARD SHAD	2399	.571	3537	208.002	20.99	125	202	158
COHO SALMON	4	<.001	6	2.728	.03	4	298	463
RAINEOW SNET	2	<.001	3	.059	.02	2	160	20
NORTHERN PIKE	1	<.001	1	.643	<.01	1	412	436
GOLDFISH	279	.066	411	44.232	2.44	117	181	135
CARP	39	.009	58	5.983	.34	39	163	104
SILVER CHUB	5	<.001	7	.208	.04	5	148	28
EMERALD SHINER	4254	1.012	6272	27.529	37.21	123	90	5
SPOTTAIL SHINER	1843	.439	2717	20.561	16.12	125	96	9
FATHEAD MINNOW	1	<.001	1	.003	<.01	1	68	2
CREEK CHUB	1	<.001	1	.035	<.01	1	138	24
CARP X GOLDFISH	2	<.001	3	1.982	.02	2	327	672
OUTLACK	5	<.001	7	.960	.04	5	191	130
WHITE SUCKER	8	<.001	12	.935	.07	8	178	84
BROWN BULLHEAD	4	<.001	6	.485	.03	4	168	82
CHANNEL CATFISH	57	.014	84	4.742	.50	54	143	59
TAYPOLE MADON	42	.010	62	.417	.37	42	93	7
TROUT-PERCH	87	.021	128	.954	.04	80	82	7
WHITE PERCH	11	<.001	16	.450	.19	11	93	7
WHITE BASS	307	.073	453	38.651	2.69	124	199	139
ROCK BASS	2	<.001	3	.081	.02	2	108	28
PUMPKINSEED	18	<.001	27	1.231	.16	18	130	46
ORANGESPOTTED SUNFISH	10	<.001	15	.116	.09	10	68	8
SHALMOUTH BASS	1	<.001	1	.016	<.01	1	101	11
LARGEMOUTH BASS	1	<.001	3	.498	<.01	1	274	338
WHITE CRAWFIE	2	<.001	3	.004	.02	2	71	2
BLACK CRAWFIE	8	<.001	12	1.157	.07	8	138	98
YELLOW PERCH	1856	.442	2736	123.733	16.24	127	170	60
LOGPERCH	34	<.001	50	.349	.30	34	94	7
WALLEYE	35	<.001	52	13.312	.31	35	280	258
FRESHWATER DRUM	103	.025	152	10.511	.90	73	177	72
TOTAL	11431	2.720	16854	510.968				
NUMBER OF SPECIES	34							
SAMPLING TIME (HRS)	146.50							
INTAKE VOL. (CU.M)	6198699							

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TABLE 5-5. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 8 MONITORING PERIODS IN JUNE 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT.(KG)	FCT. NO.	COMP. WT.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN WEIGHT(GM)
ALEWIFE	110	.017	111	3.689	2.08	1.85	84	173	33
GIZZARD SHAD	1458	.219	1468	78.194	27.57	39.19	100	188	95
COHO SALMON	4	<.001	4	.145	.08	.07	4	170	36
CHINOOK SALMON	2	<.001	2	.053	.04	.03	2	159	27
RAINBOW SMELT	26	<.001	26	.465	.49	.23	26	158	18
GOLDFISH	129	.019	130	22.494	2.44	11.27	68	195	164
CARP	6	<.001	6	1.879	.11	.94	6	249	311
SILVER CHUB	9	<.001	9	.316	.17	.16	9	157	35
EMERALD SHINER	798	.120	803	3.861	15.09	1.94	55	91	5
SPOTTAIL SHINER	1662	.250	1673	10.795	31.42	5.41	100	92	6
CREEK CHUB	1	<.001	1	.013	.02	<.01	1	112	13
QUILLBACK	12	<.001	12	3.978	.23	1.99	12	236	329
WHITE SUCKER	3	<.001	3	.072	.06	.04	3	127	24
BLACK BULLHEAD	3	<.001	3	.237	.06	.12	3	149	78
BROWN BULLHEAD	11	<.001	11	.898	.21	.45	11	160	81
CHANNEL CATFISH	9	<.001	9	.041	.17	.02	9	83	5
STONECAT	1	<.001	1	.017	.02	<.01	1	128	17
TADPOLE MADTOM	14	<.001	14	.082	.26	.04	14	75	6
TROUT-PERCH	44	<.001	44	.274	.83	.14	21	94	7
WHITE PERCH	1	<.001	1	.014	.02	<.01	1	116	14
WHITE BASS	111	.017	112	14.358	2.10	7.20	37	218	137
ROCK BASS	4	<.001	4	.347	.08	.17	4	132	86
PUMPKINSEED	6	<.001	6	.321	.11	.16	6	139	53
ORANGESPOTTED SUNFISH	17	<.001	17	.246	.32	.12	17	76	14
WHITE CRAPPIE	1	<.001	1	.201	.02	.10	1	290	200
BLACK CRAPPIE	2	<.001	2	.533	.04	.27	2	258	265
YELLOW PERCH	592	.089	596	29.476	11.19	14.77	101	168	58
LOGPERCH	11	<.001	11	.086	.21	.04	11	98	8
WALLEYE	45	<.001	45	6.514	.85	3.26	45	237	144
FRESHWATER DRUM	197	.030	198	19.928	3.72	9.99	67	201	129

TOTAL	5289	.794	5324	199.529
NUMBER OF SPECIES	30			
SAMPLING TIME (HRS)	190.75			
INTAKE VOL. (CU.M)	6703943			

TABLE 5-6. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 5 MONITORING PERIODS IN JULY 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT		PCT. COMP. NO.	WT.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN WEIGHT(GM)
			NO.	WT.(KG)					
ALEWIFE	9	<.001	9	.352	.83	1.28	9	154	40
GIZZARD SHAD	159	.035	154	6.884	14.72	25.00	102	124	48
GOLDFISH	31	.007	30	5.370	2.87	19.50	31	202	179
CARP	1	<.001	<1	.078	.09	.28	1	203	81
SILVER CHUB	1	<.001	<1	.008	.09	.03	1	98	8
GOLDEN SHINER	1	<.001	<1	.005	.09	.02	1	76	5
EMERALD SHINER	26	.006	25	.094	2.41	.34	26	73	4
SPOTTAIL SHINER	55	.012	53	.245	5.09	.96	55	89	5
WHITE SUCKER	2	<.001	2	.083	.19	.30	2	148	43
SHORthead REDHORSE	1	<.001	<1	.205	.09	.75	1	320	212
BROWN BULLHEAD	1	<.001	<1	.052	.09	.19	1	166	54
CHANNEL CATFISH	1	<.001	<1	.004	.09	.01	1	126	4
TADPOLE MADTOM	2	<.001	2	.008	.19	.03	2	79	4
TROUT-PERCH	4	<.001	4	.017	.37	.06	4	89	5
WHITE PERCH	2	<.001	2	.036	.19	.13	2	91	19
WHITE BASS	153	.034	148	1.257	14.17	4.57	60	78	18
ROCK BASS	1	<.001	<1	.108	.09	.39	1	181	112
ORANGESPOTTED SUNFISH	4	<.001	4	.022	.37	.08	4	60	6
BLACK CRAPPIE	2	<.001	2	.516	.19	1.87	2	256	267
GREEN X BLUEGILL	1	<.001	<1	.013	.09	.05	1	89	13
YELLOW PERCH	208	.046	201	8.835	19.26	32.08	116	154	44
LOGPERCH	1	<.001	<1	.004	.09	.01	1	47	4
WALLEYE	8	<.001	8	.504	.74	1.83	8	150	65
FRESHWATER DRUM	406	.089	393	2.816	37.59	10.23	67	107	30
TOTAL	1080	.238	1045	27.536					
NUMBER OF SPECIES	24								
SAMPLING TIME (HRS)	124.00								
INTAKE VOL. (CU.M)	4398634								

TABLE 5-7. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 4 MONITORING PERIODS IN AUGUST 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT		PCT. COMP. NO.	WT. WT. (KG)	NUMBER MEASURED	MEAN TOTAL LENGTH (MM)	MEAN WEIGHT (GM)
			NO.	WT. (KG)					
ALEWIFE	9	<.001	9	.058	.36	.08	9	80	6
GIZZARD SHAD	634	.160	631	27.068	25.18	37.82	80	147	48
NORTHERN PIKE	3	<.001	3	.231	.12	.32	3	230	77
GOLDFISH	42	.011	42	7.741	1.67	10.81	42	199	185
CARP	4	<.001	4	.092	.16	.13	4	118	23
EMERALD SHINER	29	.007	29	.093	1.15	.13	29	80	3
SPOTTAIL SHINER	23	.006	23	.153	.91	.21	23	90	7
CARP X GOLDFISH	1	<.001	<1	.013	.04	.02	1	96	13
QUILLBACK	1	<.001	<1	.288	.04	.40	1	290	290
WHITE SUCKER	5	<.001	5	.038	.20	.05	5	95	8
SHORTHEAD REDHORSE	4	<.001	4	.037	.16	.05	4	98	9
BROWN BULLHEAD	1	<.001	<1	.159	.04	.22	1	254	160
CHANNEL CATFISH	3	<.001	3	.007	.12	<.01	3	67	2
WHITE PERCH	1	<.001	<1	.005	.04	<.01	1	76	5
WHITE BASS	321	.081	319	1.751	12.75	2.45	80	79	16
ROCK BASS	1	<.001	<1	.114	.04	.16	1	177	115
PUMPKINSEED	1	<.001	<1	.057	.04	.08	1	125	57
ORANGESPOTTED SUNFISH	1	<.001	<1	.009	.04	.01	1	81	9
YELLOW PERCH	464	.117	462	24.948	18.43	34.85	80	154	48
LOGPERCH	1	<.001	<1	.005	.04	<.01	1	88	5
WALLEYE	14	<.001	14	1.389	.56	1.94	14	192	100
FRESHWATER DRUM	955	.240	950	7.324	37.93	10.23	83	101	15
TOTAL	2518	.634	2505	71.578					
NUMBER OF SPECIES	22								
SAMPLING TIME (HRS)	96.50								
INTAKE VOL. (CU.M)	3951958								



TABLE 5-8. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 7 MONITORING PERIODS IN SEPTEMBER 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT		PCT. COMP. NO.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)		MEAN WEIGHT(GM)
			NO.	WT. (KG)			LENGTH(MM)	WEIGHT(GM)	
ALEWIFE	30	<.001	32	.257	.77	30	90	8	
GIZZARD SHAD	2225	.302	2373	35.148	57.15	140	135	35	
GOLDFISH	16	<.001	17	2.675	.41	16	195	157	
CARP	6	<.001	6	1.497	.15	6	202	234	
EMERALD SHINER	86	.012	92	.313	2.21	54	81	4	
SPOTTAIL SHINER	44	<.001	47	.205	1.13	44	78	4	
FATHEAD MINNOW	1	<.001	1	.003	.03	1	62	3	
QUILLBACK	1	<.001	1	.004	.03	1	76	4	
WHITE SUCKER	3	<.001	3	.026	.08	3	98	8	
BROWN BULLHEAD	3	<.001	3	.457	.08	3	230	143	
CHANNEL CATFISH	18	<.001	19	.302	.46	18	84	16	
TADPOLE MADTOM	1	<.001	1	.007	.03	1	84	7	
WHITE PERCH	1	<.001	1	.004	.03	1	75	4	
WHITE BASS	255	.035	272	1.187	6.55	107	69	8	
GREEN SUNFISH	1	<.001	1	.014	.03	1	95	13	
PUMPKINSEED	1	<.001	1	.069	.03	1	151	65	
ORANGESPOTTED SUNFISH	4	<.001	4	.020	.10	4	65	5	
YELLOW PERCH	245	.033	261	14.974	6.29	98	156	54	
LOGPERCH	26	<.001	28	.131	.67	26	82	5	
WALLEYE	10	<.001	11	1.567	.26	10	219	147	
FRESHWATER DRUM	916	.124	977	14.177	23.53	140	125	25	
TOTAL	3893	.529	4153	73.037					
NUMBER OF SPECIES	21								
SAMPLING TIME (HRS)	157.50								
INTAKE VOL. (CU.M)	7854706								

TABLE 5-9. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 9 MONITORING PERIODS IN OCTOBER 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT. (KG)	PCT. COMP. NO.	COMP. WT.	NUMBER MEASURED	MEAN LENGTH (MM)	MEAN WEIGHT (MM)
LONGHORN DOG	1	.001	1	.050	<.01	<.01	1	206	46
ALBACORE	100	.004	127	.987	.07	.12	42	93	8
GLAZER SHAD	130012	10.004	174049	660.520	95.02	83.30	237	107	22
ROBINSON SHAD	1	.001	1	.063	<.01	<.01	1	195	50
COPI	115	.016	146	8.356	.00	1.03	79	136	59
SILVER CHUB	16	.001	20	2.131	.01	.27	16	143	106
EMERALD SHADDER	3	.001	4	1.104	<.01	.02	3	173	40
SOUTHERN SHADDER	527	.072	731	2.704	.40	.37	127	83	4
FAIRBANK SHADDER	136	.019	172	.983	.09	.12	84	71	3
BLACK CHUB	1	.001	1	.004	<.01	<.01	1	79	5
CARP X GO DFTSH	1	.001	1	.006	<.01	<.01	1	93	12
WHITE SUCKER	4	.001	0	.090	<.01	.01	4	107	21
WHITE SUCKER	2	.001	9	.312	<.01	.04	3	138	23
HEMMILL LUTAD	1	.001	3	.057	<.01	<.01	2	268	201
CHANNEL CATFISH	240	.034	314	1.112	<.01	.03	103	72	4
LEWIS FISH	1	.001	1	.005	<.01	<.01	1	67	4
WHITE PERCH	2	.001	3	.011	<.01	<.01	2	75	5
WHITE PERCH	4	.001	5	.105	<.01	.01	4	107	21
WHITE BASS	1032	.141	1307	5.205	.72	.69	190	73	7
BLACK BASS	4	.001	5	.205	<.01	.03	4	122	41
GREEN SUNFISH	22	.001	28	.084	.02	.01	5	52	3
PURKINGFISH	0	.001	10	.481	<.01	.06	8	122	48
ORANGE-SPIKED SUNFISH	10	.001	23	.037	<.01	<.01	10	51	2
BLACK CRAPPIE	8	.001	10	.213	<.01	.03	4	92	40
GREEN X BLUEGILL	9	.001	11	.480	<.01	.06	4	103	48
YELLOW PERCH	5	.001	6	.013	<.01	<.01	1	49	2
LONGPERCH	524	.001	753	54.811	.41	6.92	201	178	72
WALLEYE	117	.016	140	.861	.08	.11	91	83	6
WALLEYE	7	.001	9	.698	<.01	.09	7	204	79
WALLEYE	282	.408	3770	50.647	2.07	6.39	215	118	29
TRE SHADDER DRUM									
TOTAL	144045	19.709	182405	792.213					
NUMBER OF SPECIES	31								
SAMPLING TIME (HRS)	170.50								
INTAKE CU. (CU.F)	9259000								

TABLE 5-10. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 8 MONITORING PERIODS IN NOVEMBER 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT. (KG)	FCT. NO.	COMP. WT.	NUMBER MEASURED	MEAN TOTAL LENGTH (MM)	MEAN WEIGHT (GM)
ALEWIFE	3	<.001	33	.266	<.01	<.01	3	97	8
GIZZARD SHAD	48557	99.431	759747	3547.690	98.77	95.60	240	86	10
BULLFISH	79	.115	875	33.691	.11	.91	68	122	40
CARP	11	.016	122	2.592	.02	.07	11	108	21
EMERALD SUNNER	324	.470	3590	13.782	.47	.37	95	81	4
SPOTTAIL SHINER	39	.057	432	2.302	.06	.06	39	84	6
WHITE SUCKER	1	<.001	11	.144	<.01	<.01	1	113	13
SHORTHEAD REHURSE	2	<.001	22	1.485	<.01	.04	2	171	67
CHANNEL CATFISH	7	.010	78	.687	.01	.02	7	90	9
TROUT-PERCH	1	<.001	11	.055	<.01	<.01	1	90	5
WHITE PERCH	5	<.001	55	.443	<.01	.01	5	83	8
WHITE BASS	221	.321	2448	18.037	.32	.49	144	74	9
GREEN SUNFISH	2	<.001	22	.089	<.01	<.01	2	58	4
ORANGESPOTTED SUNFISH	1	<.001	11	.022	<.01	<.01	1	53	2
BLUEGILL	1	<.001	11	.022	<.01	<.01	1	51	2
WHITE CROPPIE	1	<.001	11	.033	<.01	<.01	1	64	3
BLACK CROPPIE	1	<.001	11	.011	<.01	<.01	1	50	1
YELLOW PERCH	83	.120	920	61.755	.12	1.66	83	166	67
LOGPERCH	15	.022	166	1.119	.02	.03	15	86	7
WALLEYE	2	<.001	27	17.693	<.01	.48	2	387	799
FRESHWATER DRUM	57	.083	632	8.852	.08	.24	57	99	14
TOTAL	69413	100.672	769030	3710.851					
NUMBER OF SPECIES	21								
SAMPLING TIME (HRS)	17.33								
INTAKE VOL. (CU.M)	7630936								

TABLE 5-11. SUMMARY OF FISH IMPINGED (NUMBER/1000 M³) AND CUMULATIVE DAILY ESTIMATED IMPINGEMENT (NUMBER, WEIGHT) DURING 9 MONITORING PERIODS IN DECEMBER 1979 AT THE J.R. WHITING PLANT.

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED IMPINGEMENT NO.	WT.(KG)	PCT. COMP. NO.	WT.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN WEIGHT(GM)
ALBITE	21	.010	75	.540	.04	.05	21	97	7
GLAZARD SHAD	51444	24.454	182912	1158.258	98.37	96.73	242	99	16
NORTHERN PINE	1	<.001	4	1.554	<.01	.13	1	398	437
GOLDFISH	82	.039	292	6.983	.16	.58	82	102	24
CARP	18	<.001	64	1.486	.03	.12	18	103	23
EMERALD SHINER	313	.149	1113	4.363	.60	.36	122	83	4
SPOTTAIL SHINER	80	.038	284	2.297	.15	.19	66	91	8
CROOK CHUB	1	<.001	4	.014	<.01	<.01	1	65	4
CARP X GOLDFISH	1	<.001	4	.037	<.01	<.01	1	102	16
BULL BUCK	1	<.001	4	.028	<.01	<.01	1	89	8
WHITE SUCKER	1	<.001	4	.048	<.01	<.01	1	119	19
SHORTEAD EELHORSE	1	<.001	4	.039	<.01	<.01	1	108	11
CHANNEL CATFISH	4	<.001	14	.036	<.01	<.01	4	63	3
TROUT-PEACH	3	<.001	11	.046	<.01	<.01	3	77	4
WHITE PERCH	3	<.001	11	.060	<.01	<.01	3	73	6
WHITE BASS	176	.084	626	6.041	.34	.50	151	84	10
GREEN SUNFISH	9	<.001	32	.107	.02	<.01	9	54	3
PUMPKINSEED	5	<.001	18	.188	<.01	.02	5	69	11
OKONG SPOTTED SUNFISH	8	<.001	28	.135	.02	.01	8	62	5
SMALLMOUTH BASS	1	<.001	4	.046	<.01	<.01	1	99	13
WHITE CRAFTIE	1	<.001	4	.011	<.01	<.01	1	61	3
BLACK CRAFTIE	2	<.001	7	1.188	<.01	.10	2	170	167
YELLOW PERCH	76	.036	270	11.801	.15	.99	76	143	44
LOGPERCH	4	<.001	14	.075	<.01	<.01	4	82	5
WALLEYE	1	<.001	4	.836	<.01	.07	1	290	235
FRESHWATER DRUM	40	.019	142	1.216	.08	.10	40	83	9

TOTAL 52297 24.859 185945 1197.472

NUMBER OF SPECIES 26
SAMPLING TIME (HRS) 60.75
INTAKE VOL. (CU.H) 7479251

TABLE 5-12. SUMMARY OF ESTIMATED IMPINGEMENT (NUMBERS) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

SPECIES	2 APR - 30 APR	1 MAY - 31 MAY	1 JUN - 1 JUL	2 JUL - 3 AUG	4 AUG - 3 SEP	4 SEP - 30 SEP
SILVER LAMPREY	24	1	0	0	0	0
LONGNOSE GAR	0	0	0	0	0	0
ALBITE	0	27	375	54	63	150
GIZZARD SHAD	166024	11749	4476	915	4619	9234
CHUB SALMON	21	31	11	0	0	0
CHUMOK SALMON	6	0	6	0	0	0
RAINBOW SWEET	191	7	77	0	0	0
CENTRAL HADDOCK	5	0	0	0	0	0
NORTHERN PIKE	0	5	0	0	25	0
GOLDFISH	13982	1166	412	185	323	70
CARP	2310	299	22	8	22	25
SILVER CHUB	0	25	28	3	0	0
GOLDEN SHINER	0	0	0	3	0	0
EMERALD SHINER	371324	14339	2269	129	193	531
COMMON SHINER	6	0	0	0	0	0
SPOTTAIL SHINER	38707	10719	5272	369	156	245
EATHEAD MINNOW	3	15	0	0	0	5
CRICK CHUB	7	1	3	0	0	0
CARP X GOLDFISH	42	10	0	0	9	0
BULLBACK	9	39	36	0	9	10
WHITE SUCKER	196	46	11	8	34	23
SPOUTHEAD REDHORSE	37	0	0	6	36	0
BLACK BULLHEAD	451	16	10	0	0	0
YELLOW BULLHEAD	3	0	0	0	0	0
BROWN BULLHEAD	1066	397	36	6	6	12
CHANNEL CATFISH	392	400	28	6	23	81
STORECAT	0	0	4	0	0	0
TAMPOLE HADDOCK	111	43	46	14	0	3
FRUIT-PERCH	1714	448	135	28	0	0
WHITE PERCH	61	34	3	12	6	10
WHITE BASS	2247	2539	337	703	2376	1384
ROCK BASS	3	13	14	6	11	0
GREEN SUNFISH	22	0	0	0	0	3
PURPKINSEED	102	182	19	0	11	3
ORANGEFOOTED SUNFISH	62	76	57	27	6	17
BLUEGILL	21	0	0	0	0	0
SMALLMOUTH BASS	0	16	0	0	0	0
LARGEMOUTH BASS	0	1	0	0	0	0
WHITE CRAPPIE	18	17	5	0	0	0
BLACK CRAPPIE	79	55	6	11	0	0
GREEN X BLUEGILL	0	0	0	8	0	0
YELLOW PERCH	30387	8647	1955	1107	3320	1448
LOGPERCH	353	304	32	6	5	117
WALLEYE	205	209	142	37	95	40
FRESHWATER DRUM	645	581	630	1765	7376	4230
TOTAL	630837	52459	16456	5416	18722	17642

TABLE 5-12 (continued)

SPECIES	1 OCT - 2 NOV	2 NOV - 30 NOV	1 DEC - 28 DEC	TOTAL
SILVER LABRITY	0	0	0	25
LONGNOSE GAR	3	0	0	3
ALBINFISH	423	1858	161	3111
GLAZARD SHAD	1175021	14756587	567792	14696418
COHO SALMON	0	0	0	63
CHUMOK SALMON	0	0	0	12
RAINBOW SMELT	5	0	0	280
CENTRAL MUDMINNOW	0	0	0	5
NORTHERN PKE	0	0	16	47
GOLD FISH	591	2791	1065	20585
CARP	58	209	225	3178
SILVER CHUB	11	0	0	67
GOLDEN SHINER	0	0	0	3
EMERALD SHINER	2666	68585	3220	463256
COMMON SHINER	0	0	0	6
SPOTTAIL SHINER	658	3670	952	60750
FATHEAD MINNOW	3	0	0	26
LAKEL CHUB	3	0	6	21
CARP X GOLD FISH	19	0	8	88
QUILLBACK	29	0	19	150
MILIE SUCKER	6	14	46	385
SHORTHEAD REDHORSE	0	64	8	151
BLACK BULLHEAD	0	0	0	477
YELLOW BULLHEAD	0	0	0	3
BROWN BULLHEAD	3	0	0	1525
CHANNEL CATFISH	990	227	49	2195
STURGEON	0	0	0	4
TARPON MAUOH	5	0	0	224
TROUT PERCH	6	117	33	2482
WHITE PERCH	12	185	40	362
WHITE BASS	5316	17314	2461	34677
ROCK BASS	79	0	0	127
GREEN SUNFISH	105	55	97	283
PUMPKINSEED	92	0	95	504
ORANGE-SIDED SUNFISH	73	26	156	500
BLUEGILL	38	117	0	176
SOUTHERN BASS	0	0	6	22
LARGemouth BASS	0	0	0	1
WHITE CRAPPIE	0	14	6	60
BLACK CRAPPIE	45	14	52	262
GREEN X BLUEGILL	23	0	0	31
YELLOW PERCH	2902	1876	964	52606
LOGPERCH	482	316	79	1694
WALLEYE	22	55	7	812
WESMILLER MUDM	12015	2948	675	30865
TOTAL	1201704	14857042	578239	17378518

TABLE 5-13. SUMMARY OF ESTIMATED IMPINGEMENT (BIOMASS) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

SPECIES	2 APR - 30 APR	1 MAY - 31 MAY	1 JUN - 1 JUL	2 JUL - 3 AUG	4 AUG - 3 SEP	4 SEP - 30 SEP
SILVER LAHRPEY	1542	55	0	0	0	0
LONGNOSE GAR	0	0	0	0	0	0
ALBIEFF	0	1184	12450	2149	344	1059
GIZZARD SHAD	3614745	831886	246001	43477	195446	166104
COHO SALMON	17769	19889	402	0	0	0
CHENOOK SALMON	3060	0	171	0	0	0
EQUINOX SHELT	4606	177	1362	0	0	0
CENTRAL MUDMINNOW	70	0	0	0	1701	0
NORTHERN PIKE	0	2391	0	0	59812	10803
BULFISH	596239	142030	69562	32019	507	5892
CARP	49349	26328	6998	672	0	0
SILVER CHUB	0	693	983	14	0	0
GOLDEN SHINER	0	0	10895	498	613	1829
HERALD SHINER	1793086	65242	0	0	0	0
COMMON SHINER	146	0	33813	1844	1092	1116
SPOTTAIL SHINER	306936	68566	0	0	0	15
FATHEAD MINNOW	15	29	42	0	0	0
GREEN CHUB	215	3263	0	0	114	0
CARP X GOLDFISH	794	6991	11355	0	2539	39
OUTLBACK	222	5612	269	465	254	168
WHITE SUCKER	32477	0	0	1255	322	0
SPOTHEAD REDHORSE	1249	0	764	0	0	0
BLACK BULLHEAD	15829	1064	0	0	0	0
YELLOW BULLHEAD	33	0	0	320	895	1845
BROWN BULLHEAD	35538	16977	2598	23	55	1388
CHANNEL CATFISH	2822	2589	133	0	0	0
STONECAT	0	0	65	56	0	24
LADOLE MAITON	585	238	263	131	0	0
TROUT PERCH	13545	3618	854	219	28	39
WHITE PERCH	917	527	39	7215	13805	5195
WHITE BASS	95687	179065	43860	663	1260	0
ROCK BASS	6	235	1131	0	0	40
GREEN SUNFISH	312	0	1000	0	625	200
TURPKURSTED	6627	8175	854	142	50	70
OKANESCOLLED SUNFISH	159	687	0	0	0	0
BLUEGILL	611	0	0	0	0	0
SMALLMOUTH BASS	0	173	0	0	0	0
LARGEMOUTH BASS	0	406	1058	0	0	0
WHITE CROFTIE	71	18	1481	3375	0	0
BLACK CROFTIE	6257	6916	0	108	0	0
GREEN X BLUEGILL	0	0	97916	47715	177559	82719
YELLOW PERCH	1875144	354881	247	24	25	579
LOBFERCH	2384	1973	20100	1554	10622	5366
WALLEY	39602	47476	65171	16863	53455	57934
FRESHWATER DRUM	11614	43010	631837	160823	521123	342434
TOTAL	8730261	1842413	631837	160823	521123	342434

TABLE 5-13 (continued)

SPECIES	1 OCT - 2 NOV	2 NOV - 30 NOV	1 DEC - 28 DEC	TOTAL
SILVER LOMBAY	0	0	0	1597
LONGROSE GAR	136	0	0	136
ALBACORE	3221	13955	1157	35519
GIIZARD SHAD	4528693	88884561	3604895	102115808
COLD SAL MON	0	0	0	38060
CUTTHROCK SALMON	0	0	0	3231
PATRICK SMELT	254	0	0	6399
CENTRAL HUNTERDUM	0	0	0	70
NORTHERN FLE	0	0	7149	11241
GOLDFISH	29124	98277	23020	1060887
CARP	6131	4771	6463	107111
SILVER CHUB	581	0	0	2279
GOLDEN SHINER	0	0	0	14
EMERALD SHINER	10753	257579	12585	2153082
COMMON SHINER	0	0	0	146
SPOTTAIL SHINER	3828	23136	7042	447373
LATHEAD MINNOW	10	0	0	69
CREEK CHUB	16	0	24	325
CART X GOLDFISH	226	0	126	4522
CHILLBACK	1102	0	152	22401
WHITE SUCKER	140	185	866	40435
SHORthead REDHORSE	0	6120	87	9032
BLACK BULLHEAD	0	0	0	17657
YELLOW BULLHEAD	0	0	0	33
BROWN BULLHEAD	613	0	0	58786
CHANNEL CATFISH	3423	2541	150	13124
STONECAT	0	0	0	65
LADPOLE MADTOM	22	0	0	1208
TROUT-PERCH	28	584	151	18909
WHITE PERCH	257	796	331	3152
WHITE BASS	21843	102342	31943	500955
ROCK BASS	3516	0	0	6811
GREEN SUNFISH	315	246	300	1212
PUMPKINSEED	1510	0	1010	19148
ORANGE-SPOTTED SUNFISH	111	52	736	2869
BLUEGILL	851	234	78	1695
SMALLMOUTH BASS	0	0	0	251
LARGEMOUTH BASS	0	0	0	406
WHITE CRAPPIE	0	43	18	1207
BLACK CRAPPIE	2577	14	2800	23419
GREEN X BLUEGILL	46	0	0	154
YELLOW PERCH	205085	134762	44217	3019998
LOGPERCH	2833	2157	412	10633
WALLEYE	1724	27441	1587	155472
FRESHWATER DRUM	153958	34798	4698	441500
	4982924	89594594	3751995	110358403
10161				

TABLE 5-14. LIST OF TAXA COLLECTED BY DRIFT NETS FROM THE
DISCHARGE WATERS OF THE J. R. WHITING PLANT FROM
APRIL THROUGH OCTOBER 1979.

Gizzard shad	Carpsuckers or Buffaloes
Rainbow smelt	Channel catfish
Herrings f.	Sunfish sp.
Minnow f.	Crappie sp.
Carp or Goldfish	White bass
Emerald shiner	Perches f.
Spottail shiner	Yellow perch
Minnow sp.	Logperch
Bluntnose minnow	Freshwater drum
Unidentifiable	

TABLE 5-15. SUMMARY OF LARVAL FISH AND FISH EGGS ENTRAINED (NUMBER/1000 m³) AND CUMULATIVE ESTIMATED ENTRAINMENT BY MONTH FROM APRIL 1979 THROUGH OCTOBER 1979 AT J.R. WHITING PLANT (DAY AND NIGHT SAMPLES COMBINED).

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
EGGS	5	3.776	7018	100.0	5	1.4	----
TOTAL LARVAE	0	.000	0				
TOTAL EGGS	5	3.776	7018				
NUMBER OF TAXA	1						
SAMPLING TIME (HRS)	2.67						
INTAKE VOLUME (CU.M.)	1858432						
SAMPLE VOLUME (CU.M.)	1324.20						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMMER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
GIZZARD SHAD	3632	3050.050	11268564	93.1	292	7.8	.7
CARP OR GOLDFISH	78	65.502	242001	2.0	14	6.2	1.1
BLUNTNose MINNOW	3	2.519	9308	.1	3	9.2	1.5
MINNOWS F.	53	44.508	164437	1.4	11	5.9	.8
WHITE BASS	1	.840	3103	.0	1	8.0	1.3
SUNFISH	24	20.155	74462	.6	3	4.3	.7
YELLOW PERCH	96	80.618	297847	2.5	68	6.3	.9
PERCHES F.	3	2.519	9308	.1	3	3.7	1.0
UNIDENTIFIABLE LARVAE	10	8.398	31026	.3	0	.0	.0
EGGS	1593	1337.756	4942407	100.0	139	.9	---
<hr/>							
TOTAL LARVAE	3900	3275.109	12100055				
TOTAL EGGS	1593	1337.756	4942407				
NUMBER OF TAXA	10						
SAMPLING TIME(HRS)	5.34						
INTAKE VOLUME (CU.M.)	3694550						
SAMPLE VOLUME (CU.M.)	1190.80						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.H.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
BIZZARD SHAD	47212	20045.153	139008970	91.3	43110	10.2	.9
HERRING F.	6	2.652	17676	.0	1	15.3	1.2
RAINBOW SHLET	16	7.071	47137	.0	2	23.6	3.3
CARP OR GOLDFISH	711	314.224	2094642	1.4	102	6.6	1.1
EMERALD SHINER	69	30.494	203270	.1	10	7.1	.8
SPOTTAIL SHINER	28	12.374	82489	.1	4	23.1	4.3
MINNOWS F.	44	19.416	127626	.1	12	6.6	.8
CARPSUCKERS OR BIFFALDES	44	19.416	127626	.1	6	6.1	.7
WHITE BARS	330	145.842	972197	.6	48	12.5	2.7
SUNFISH	4	1.748	11784	.0	1	4.5	.7
CRAFTIES	8	3.536	23560	.0	1	5.9	.8
YELLOW PERCH	75	33.146	220734	.1	19	18.0	3.2
LORPERCH	16	7.071	47137	.0	2	11.4	1.5
FRESHWATER DRUM	3125	1381.081	9206410	6.0	375	5.2	1.2
EGGS	6713	2966.783	19776842	100.0	867	1.4	---
TOTAL LARVAE	51409	22843.746	152278441				
TOTAL EGGS	6713	2966.783	19776842				
NUMBER OF TAXA	16						
SAMPLING TIME (HRS)	10.49						
INTAKE VOLUME (CU.H.)	666609						
SAMPLE VOLUME (CU.H.)	2262.72						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
BIZZARD SHAD	3197	1804.105	9014621	84.8	1076	13.1	1.2
CARP OR GOLDFISH	81	45.709	228397	2.1	59	7.2	1.2
EMERALD SHINER	261	147.285	735945	6.9	125	13.7	1.9
SPOTTED SHINER	13	7.336	36656	.3	10	21.4	3.8
HERRING, FINETOOTHES SFT.	2	1.129	5639	.1	1	7.2	1.0
HERRING F.	2	1.129	5639	.1	1	5.0	.7
CHANNEL CATFISH	2	1.129	5639	.1	2	16.3	2.9
WHITE BASS	97	54.738	273512	2.6	53	19.1	4.0
SUNFISH	30	16.929	84591	.8	18	5.9	.8
CRAPIES	2	1.129	5639	.1	1	4.3	.7
FRESHWATER URON	82	46.274	231216	2.2	51	9.1	2.2
EGGS	16877	9523.890	47588289	100.0	739	1.4	
TOTAL LARVAE	3769	2126.891	10627497				
TOTAL EGGS	16877	9523.890	47588289				
NUMBER OF TAXA	12						
SAMPLING TIME(HRS)	6.68						
INTAKE VOLUME (CU.M.)	4996728						
SAMPLE VOLUME (CU.M.)	1772.07						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
GIZZARD SHAD	20	32.444	57599	55.6	18	20.0	3.7
CARP OR GOLDFISH	1	1.622	2880	2.8	1	8.4	1.5
EMERALD SHINER	5	8.111	14400	13.9	5	16.3	2.6
SPOTTAIL SHINER	1	1.622	2880	2.8	1	48.1	7.6
MINNOWS F.	1	1.622	2880	2.8	1	6.7	.8
WHITE BASS	6	9.733	17280	16.7	6	34.5	7.9
FRESHWATER DRUM	2	3.244	5760	5.6	2	8.0	2.2
EGGS	1	1.622	2880	100.0	1	1.4	---
TOTAL LARVAE	36	58.399	103679				
TOTAL EGGS	1	1.622	2880				
NUMBER OF TAXA	8						
SAMPLING TIME (HRS)	2.67						
INTAKE VOLUME (CU.M.)	1775352						
SAMPLE VOLUME (CU.M.)	616.45						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
GIZZARD SHAD	12	23.406	53425	75.0	12	11.6	1.1
EMERALD SHINER	1	1.950	4452	6.3	1	28.8	4.5
FRESHWATER DRUM	3	5.851	13356	18.8	3	11.8	2.9
TOTAL LARVAE	16	31.207	71234				
TOTAL EGGS	0	.000	0				
NUMBER OF TAXA	3						
SAMPLING TIME(HRS)	2.67						
INTAKE VOLUME (CU.M.)	2282597						
SAMPLE VOLUME (CU.M.)	512.70						

Table 5-15 (continued)

SPECIES	TOTAL NO. COLLECTED	NUMBER /1000 CU.M.	DAILY ESTIMATED ENTRAINMENT	PCT. COMP.	NUMBER MEASURED	MEAN TOTAL LENGTH(MM)	MEAN BODY DEPTH(MM)
GIZZARD SHAD	1	1.838	3806	100.0	1	14.8	.8
TOTAL LARVAE	1	1.838	3806				
TOTAL EGGS	0	.000	0				
NUMBER OF TAXA	1						
SAMPLING TIME(HRS)	2.67						
INTAKE VOLUME (CU.M.)	2070614						
SAMPLE VOLUME (CU.M.)	544.01						

TABLE 5-16. SUMMARY OF ESTIMATED ENTRAINMENT FROM APRIL THROUGH OCTOBER 1979 AT THE J.R. WHITING PLANT.

	April 1 - April 30	May 1 - May 31	June 1 - June 30	July 1 - July 28	July 29 - September 1	September 2 - October 3
Gizzard shad	0	60,996,841	431,783,080	73,971,370	1,850,410	826,296
Herrings f.	0	0	80,561	0	0	0
Rainbow smelt	0	0	155,897	0	0	0
Carp or Goldfish	0	1,319,142	4,650,228	1,327,157	75,650	0
Emerald shiner	0	0	800,509	5,258,753	906,946	69,191
Spottail shiner	0	0	290,607	214,696	43,812	0
Minnow spp.	0	0	0	55,015	0	0
Bluntnose minnow	0	41,095	0	0	0	0
Minnows f.	0	893,126	529,331	26,167	78,982	0
Carp suckers or Buffaloes	0	0	268,228	0	0	0
Channel catfish	0	0	0	28,918	0	0
White bass	0	13,697	3,359,835	1,612,915	693,475	0
Sunfish sp.	0	402,235	22,924	615,745	0	0
Crappie sp.	0	0	77,949	55,015	0	0
Yellow perch	0	1,990,802	726,608	0	0	0
Logperch	0	0	191,471	0	0	0
Perches f.	0	71,335	0	0	0	0
Freshwater drum	0	0	30,870,423	1,534,146	154,632	203,495
Unidentifiable	0	180,807	0	0	0	0
Total larvae	0	65,909,078	473,807,630	84,699,885	3,803,917	1,098,986
Total eggs	86,707	33,882,243	65,747,278	452,774,160	1,129,749	0

Table 5-16 (continued)

	October 4 - October 31	Total
✓ Gizzard shad	49,864	569,477,861
Herrings f.	0	80,561
Rainbow smelt	0	155,897
✓ Carp or Goldfish	0	7,372,177
✓ Emerald shiner	0	7,035,399
Spottail shiner	0	549,115
Minnow spp.	0	55,015
Bluntnose minnow	0	41,095
Minnows f.	0	1,527,606
Carp suckers or Buffaloes	0	268,228
Channel catfish	0	28,918
✓ White bass	0	5,679,922
✓ Sunfish sp.	0	1,040,904
Crappie sp.	0	132,964
✓ Yellow perch	0	2,717,410
Logperch	0	191,471
Perches f.	0	71,335
✓ Freshwater drum	0	32,762,696
Unidentifiable	0	180,807
Total larvae	49,864	629,369,381
Total eggs	0	553,620,137

TABLE 5-17. SUMMARY OF FISH IMPINGED (NUMBER/1000 m³) AT THE J.R. WHITING PLANT DURING THE DETERRENT NET EFFECTIVENESS TESTS.

Net Position	Date	Impingement Density #/1000 m ³	No. Spp Impinged
Net Out	Aug 15	1.298	15
	23	0.429	15
	30	0.703	13
	Sep 06	0.548	13
	10	0.908	15
Net In	Sep 10		
	14	0.213	13
	19	0.216	13
	21	0.228	11
	25	0.768	14
	27	0.805	10
	Oct 02	0.263	11
	05	0.259	12
	09	14.693	23
	11	9.600	20
Net Out	Oct 12		
	15	27.304	15
	18	18.805	14
Net In	Oct 19		
	23	36.204	15
	25	73.656	12
Net Out	Oct 29		
	31	149.762	9
	Nov 06	49.036	7
	08	185.612	11
	13	156.583	8
	15	133.445	6

TABLE 5-18. A SUMMARY OF DIVER OBSERVATIONS OF THE EFFECTIVENESS OF THE DETERRENT NET AT THE J.R. WHITING PLANT.

First Test

Date	Bottom Sealed	Float Line Above Water	Debris Impinged	Effective Block to Fish Movement
Sep 13	Yes	Yes	No	Yes
18	Yes	Yes	Top 1' of net	Yes
25	Yes, but some gaps	Yes	Top 1½' of net	Yes
Oct 02	Yes	Yes	Top 1½' of net	No
09	Poorly-between weights, 1½ to 2' above bottom	No - 1½' submerged	One drum impinged; silt and algae build- up to the point of impairing flow	No

Second Test

Date	Bottom Sealed	Float Line Above Water	Debris Impinged	Effective Block to Fish Movement
Oct 19	Yes	Yes	No	No
23	No - holes in net	No - 1-2' below surface	No	No
25	Yes	No	Top 1½' of net; sediment and leaves	No
29	Yes	No	?	No

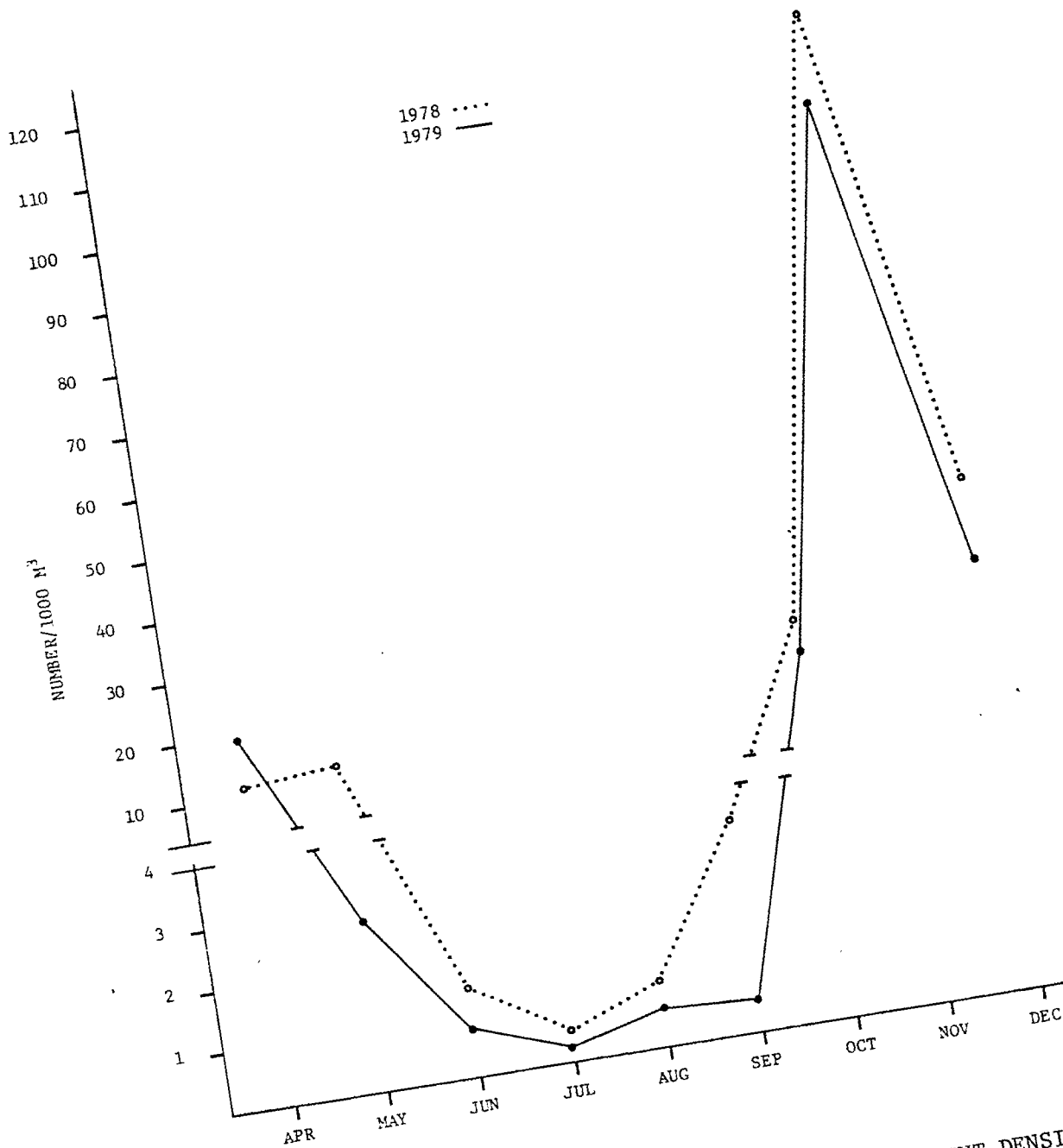


FIGURE 5-1. SUMMARY OF TOTAL TAXA CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

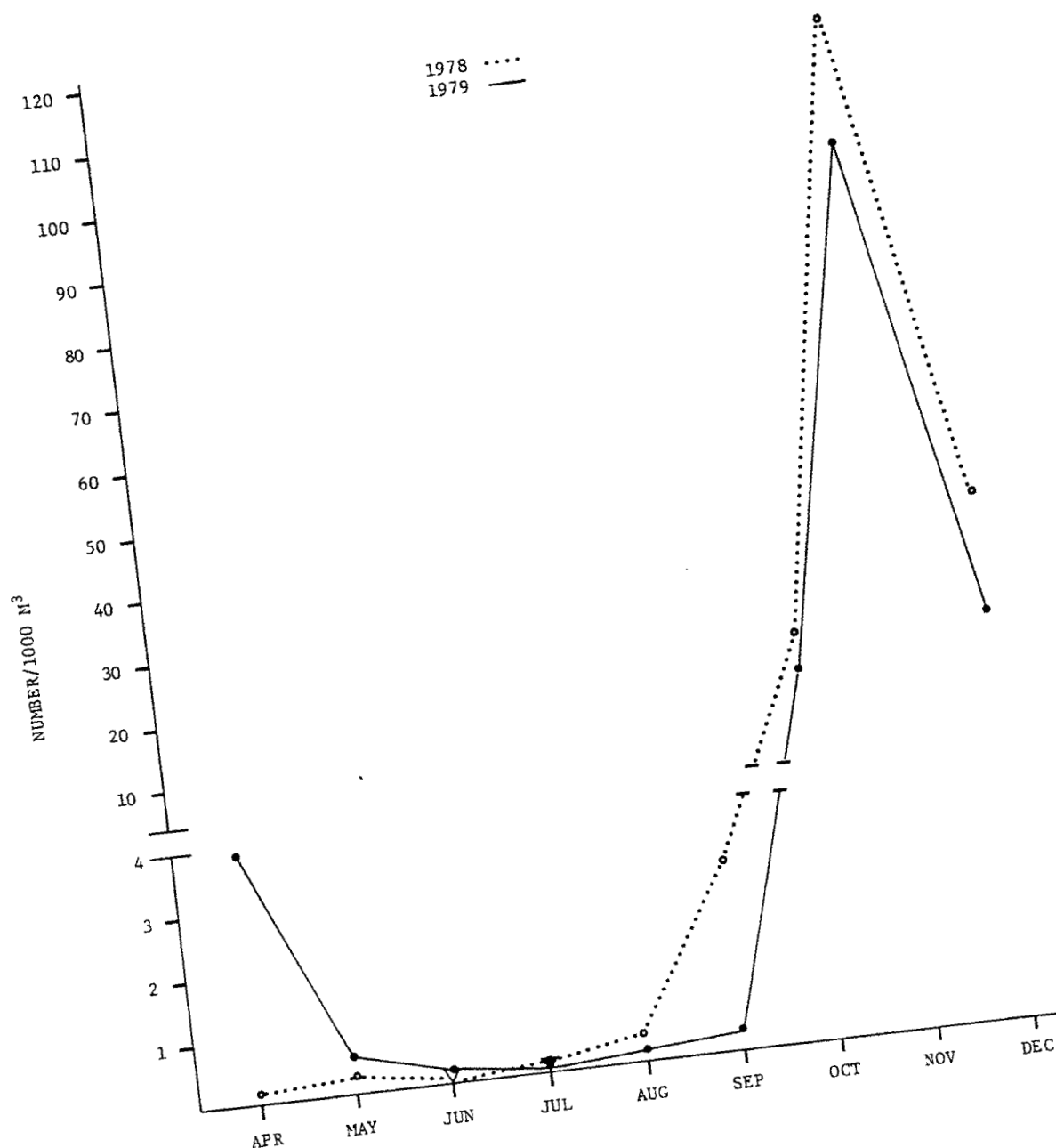


FIGURE 5-2. SUMMARY OF TOTAL GIZZARD SHAD CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

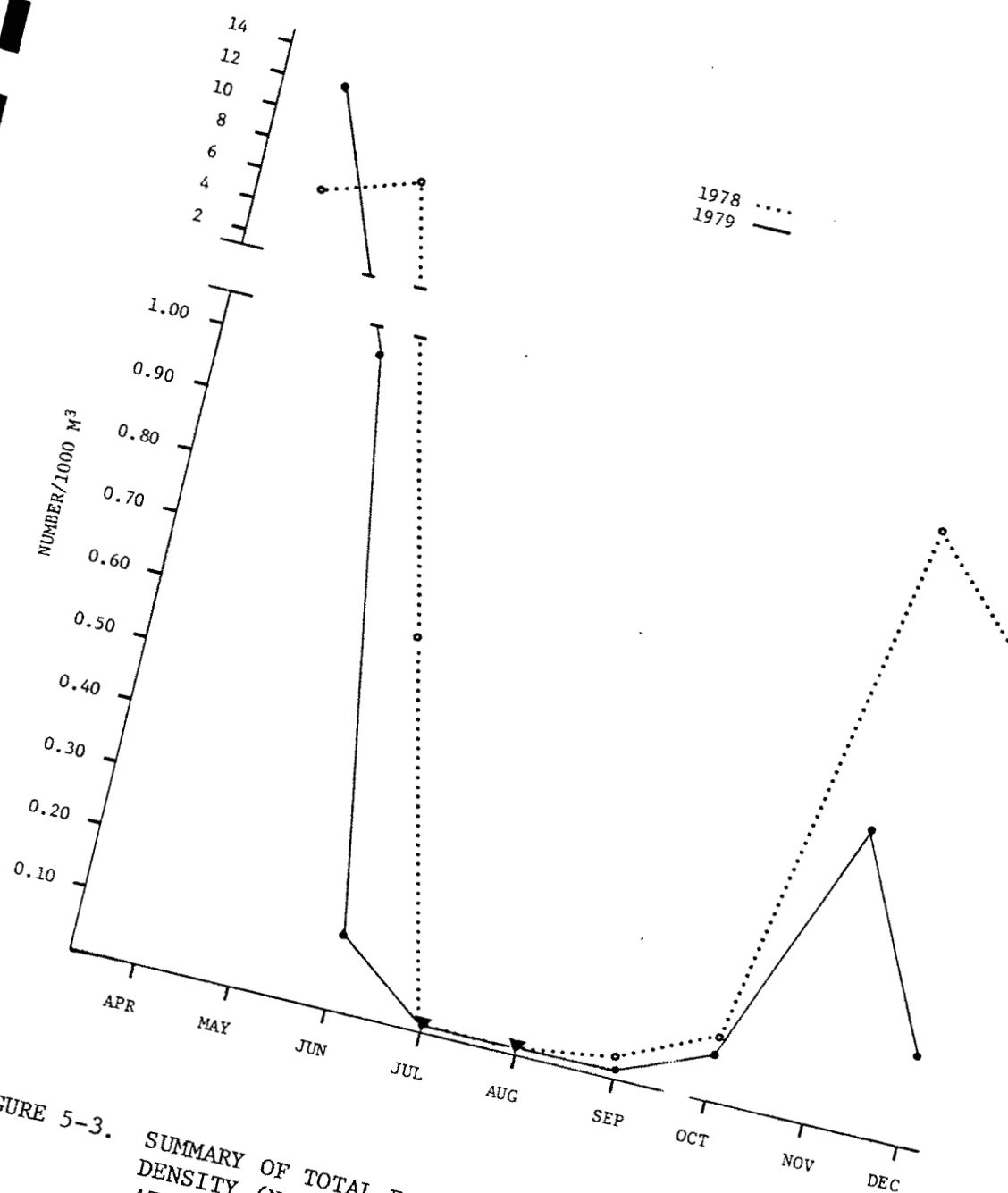


FIGURE 5-3. SUMMARY OF TOTAL EMERALD SHINER CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

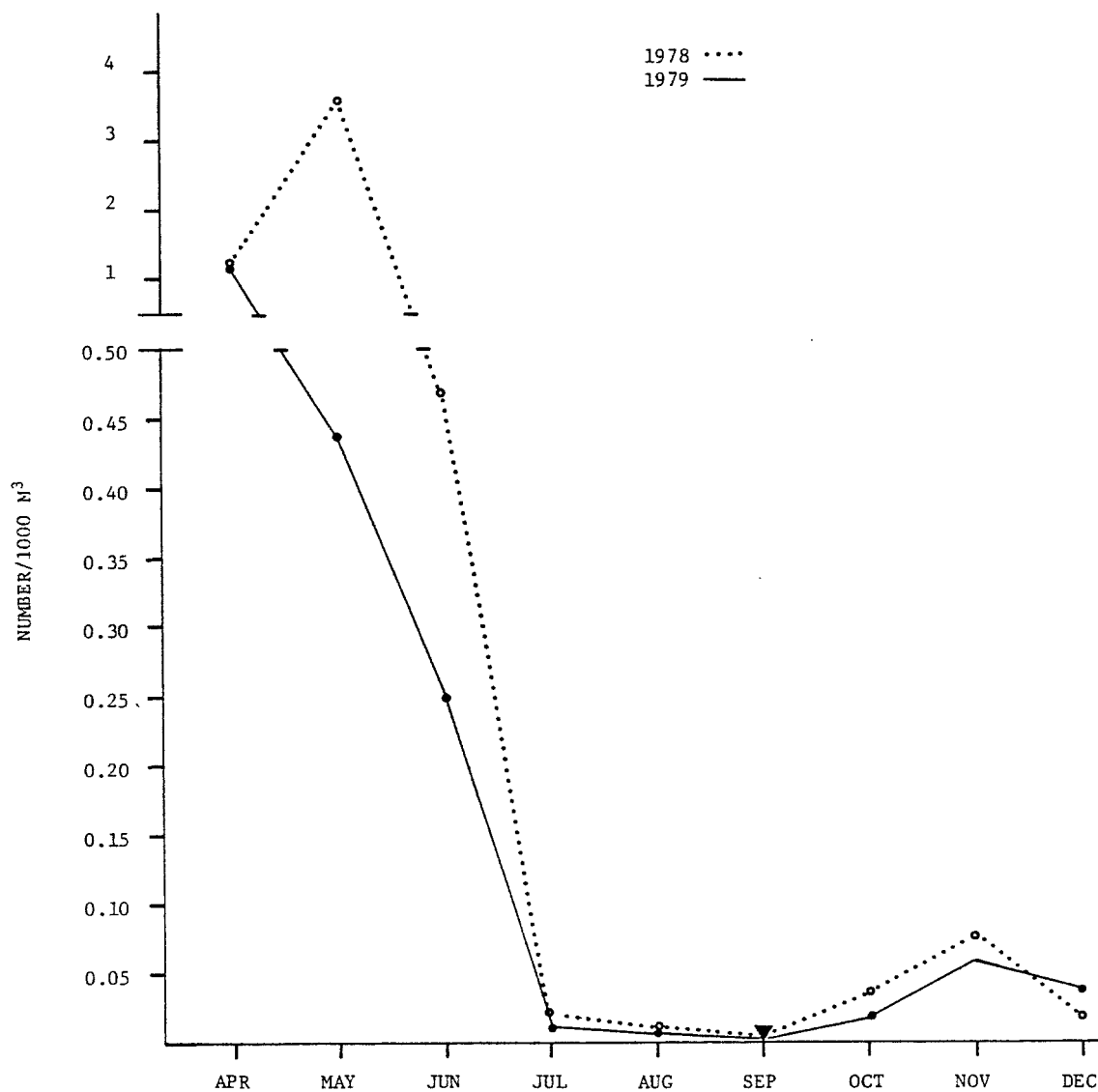


FIGURE 5-4. SUMMARY OF TOTAL SPOTTAIL SHINER CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

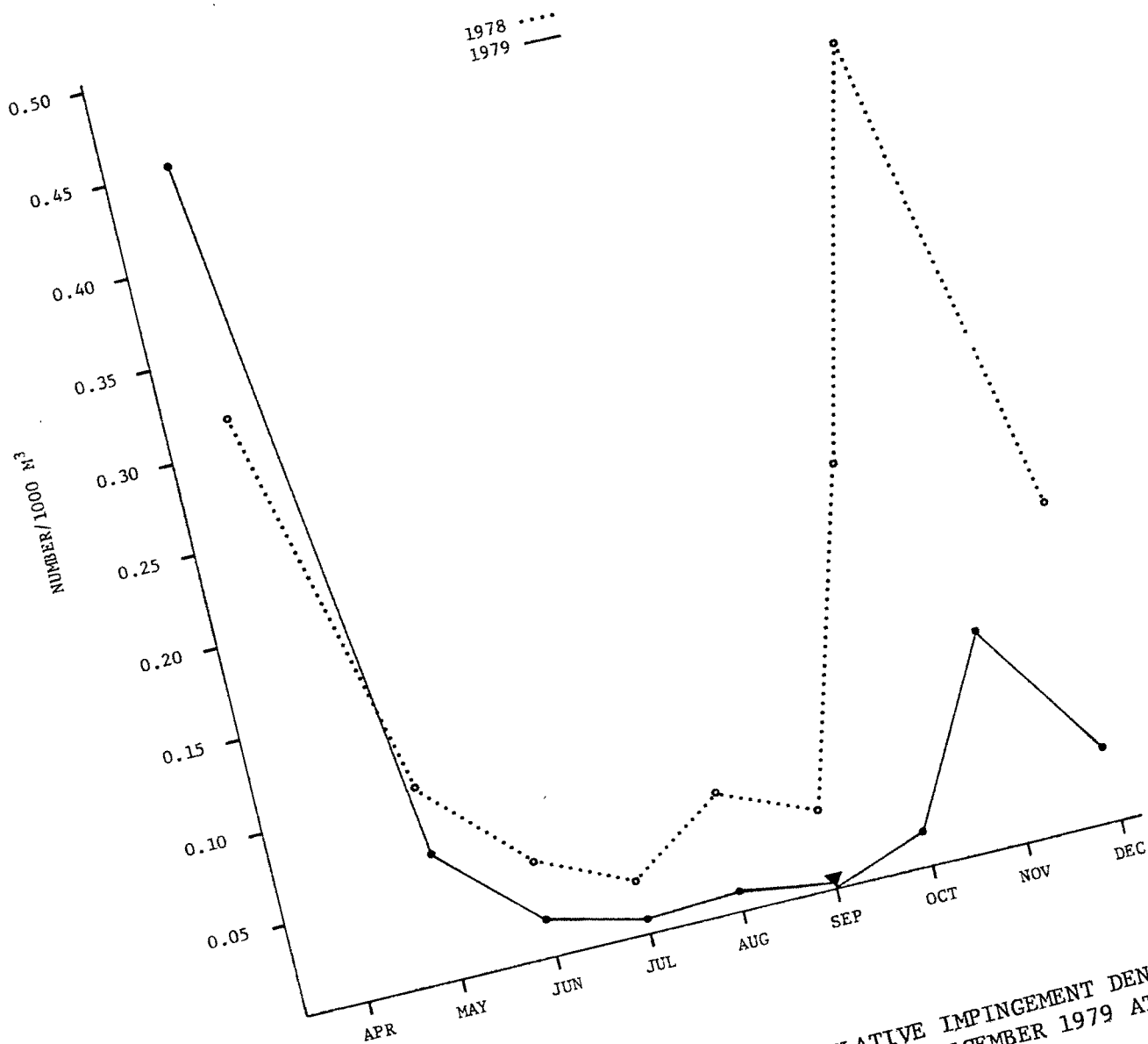


FIGURE 5-5. SUMMARY OF TOTAL GOLDFISH CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

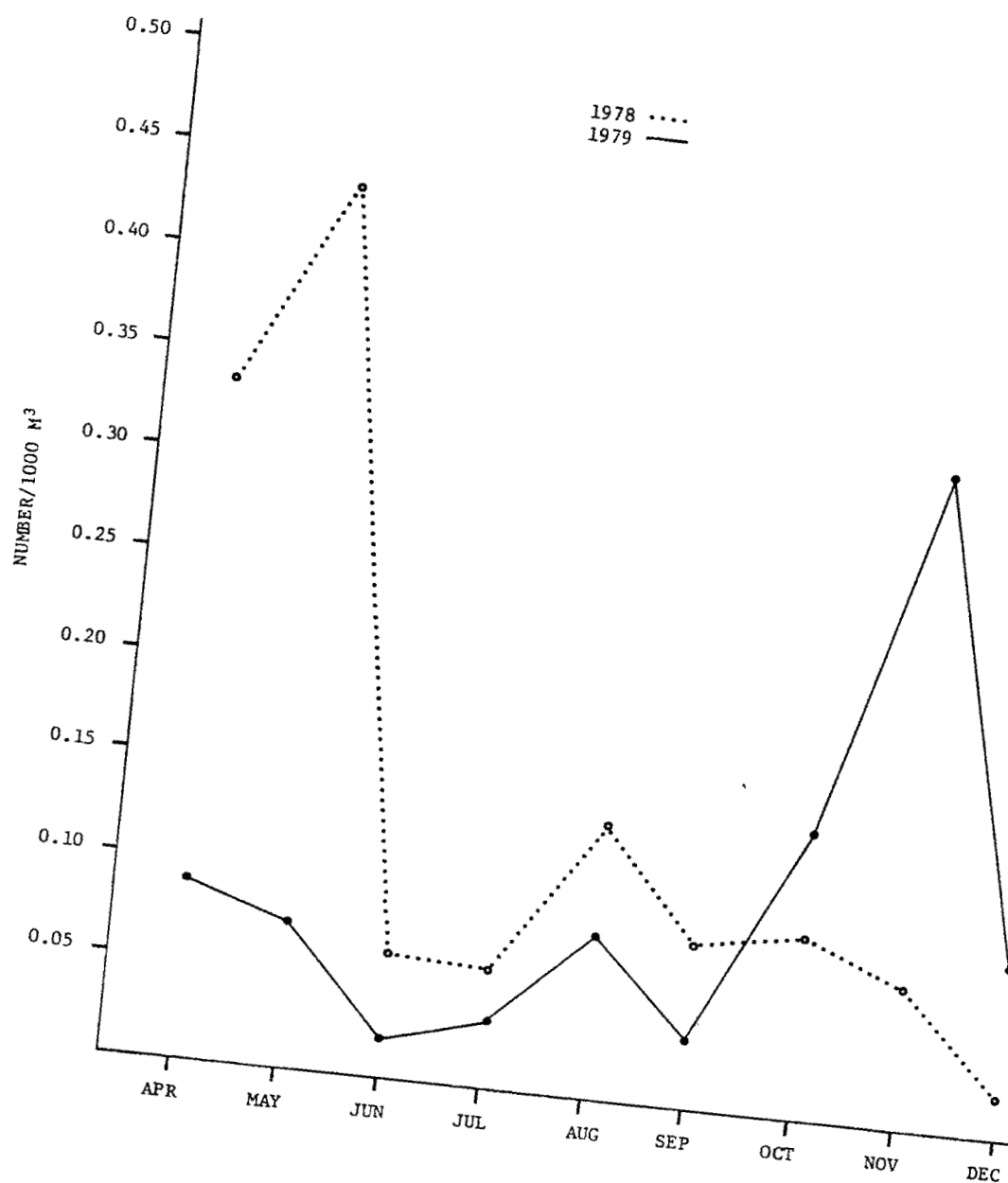


FIGURE 5-6. SUMMARY OF TOTAL WHITE BASS CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

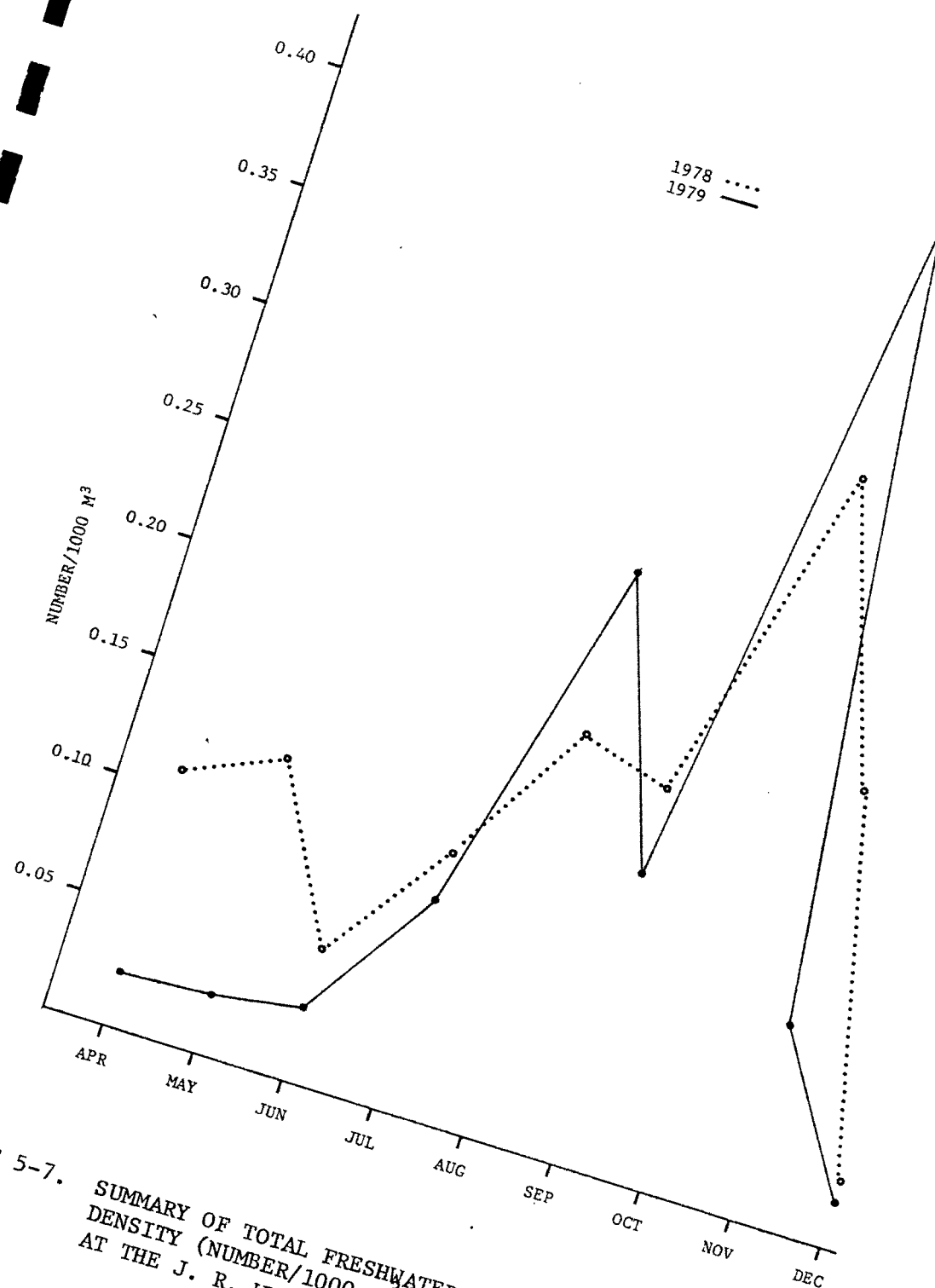


FIGURE 5-7. SUMMARY OF TOTAL FRESHWATER DRUM CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

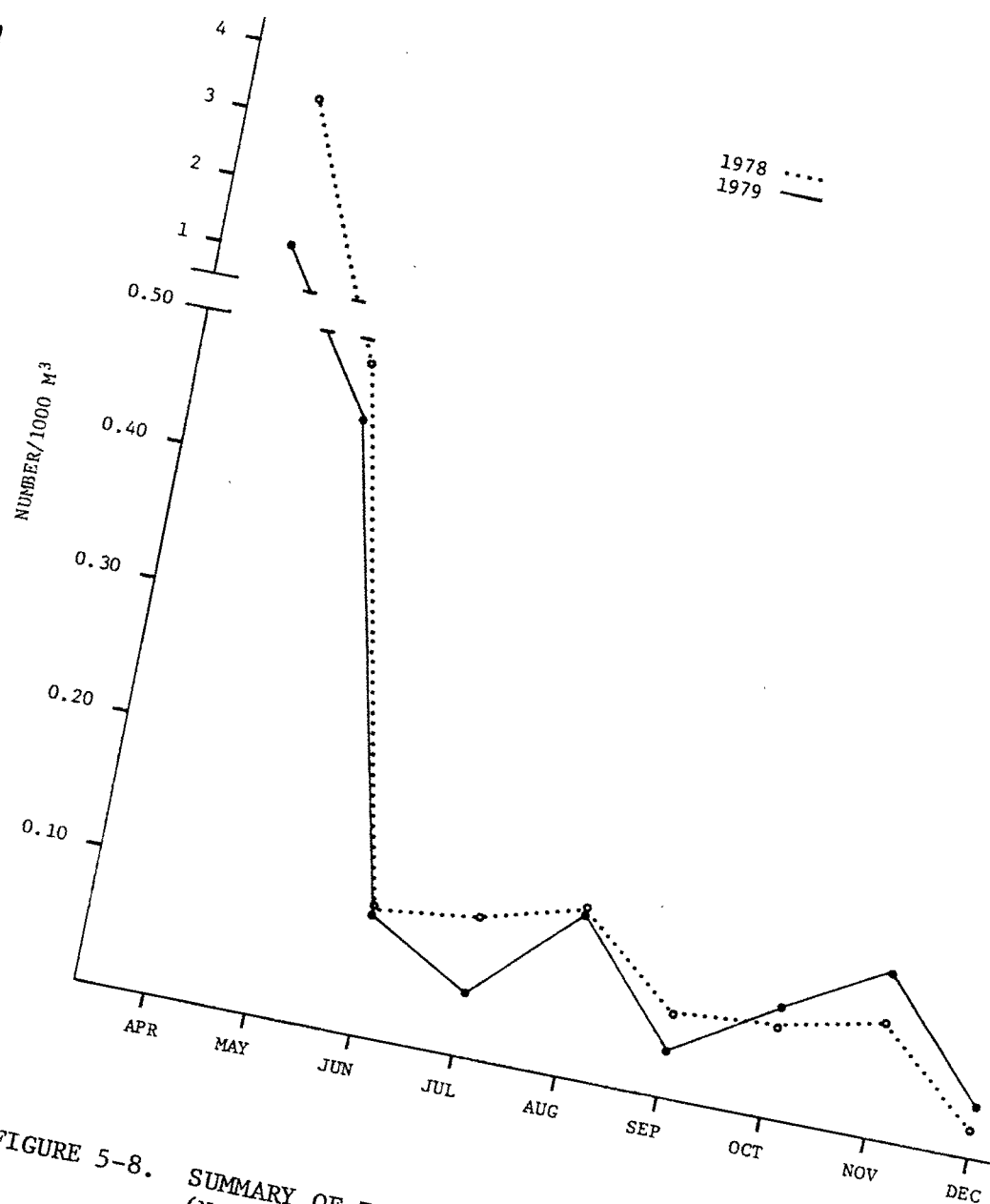


FIGURE 5-8. SUMMARY OF TOTAL YELLOW PERCH CUMULATIVE IMPINGEMENT DENSITY (NUMBER/1000 m³) FROM APRIL THROUGH DECEMBER 1979 AT THE J. R. WHITING PLANT.

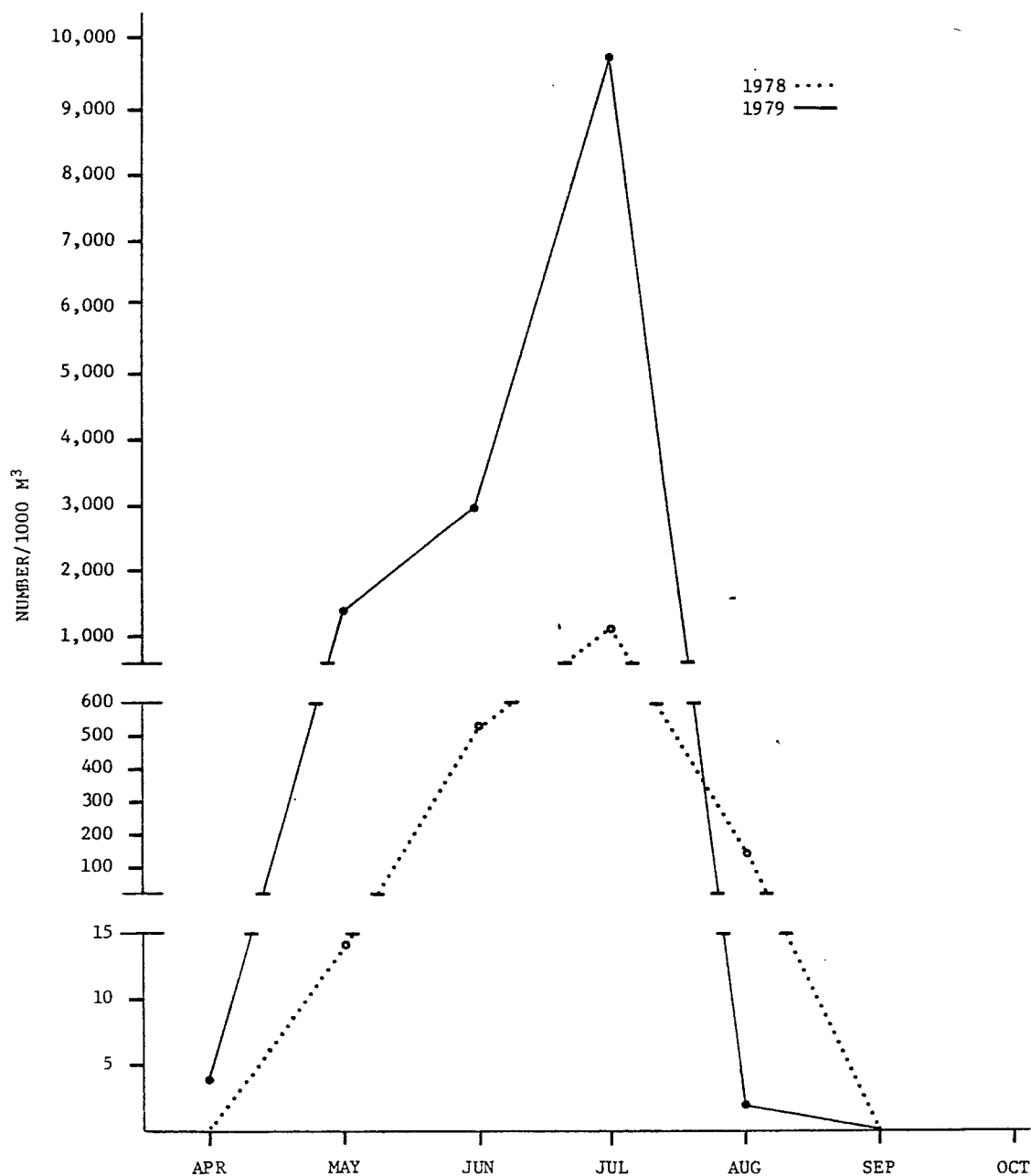


FIGURE 5-9. SUMMARY OF FISH EGG CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

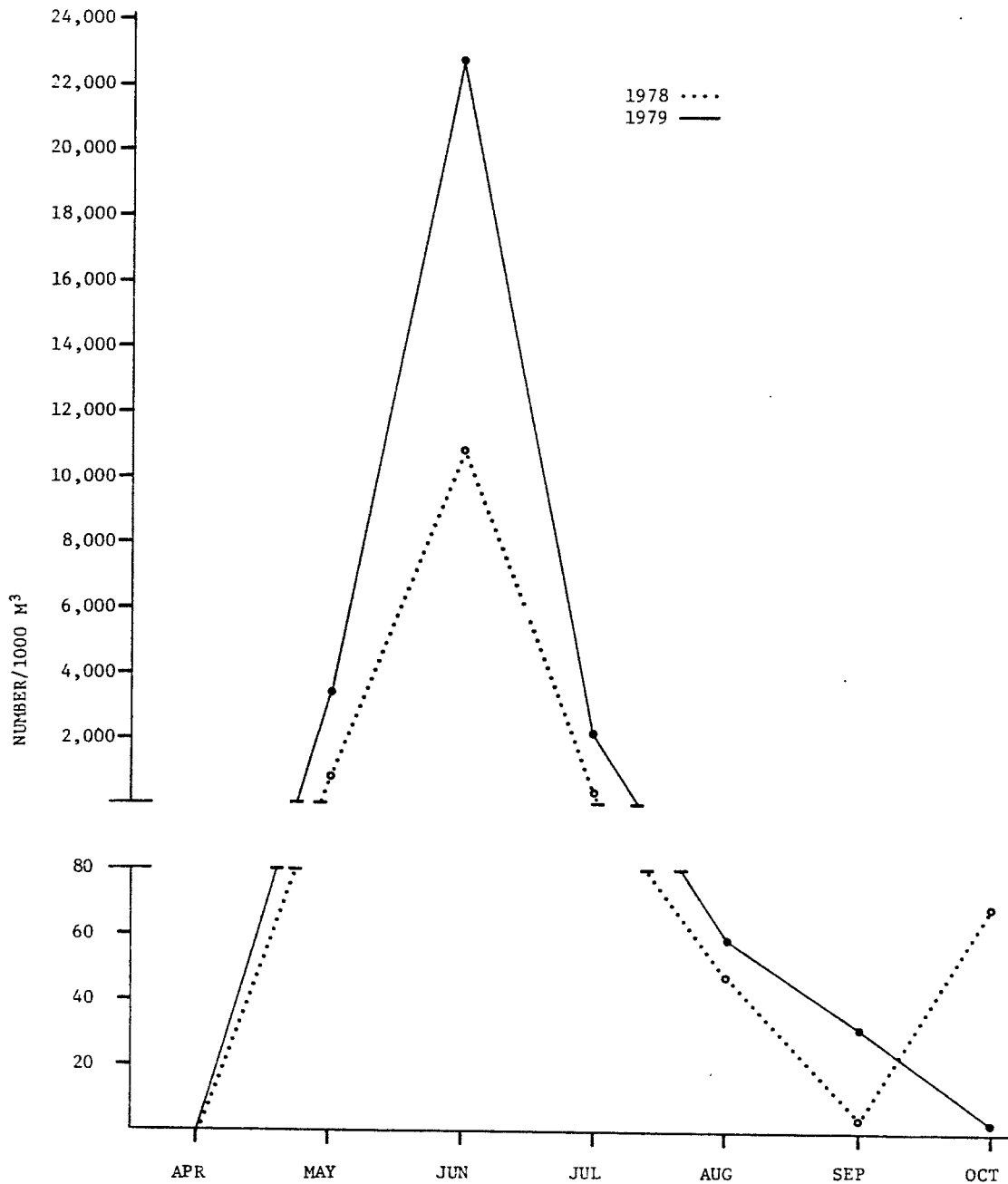


FIGURE 5-10. SUMMARY OF FISH LARVAE CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

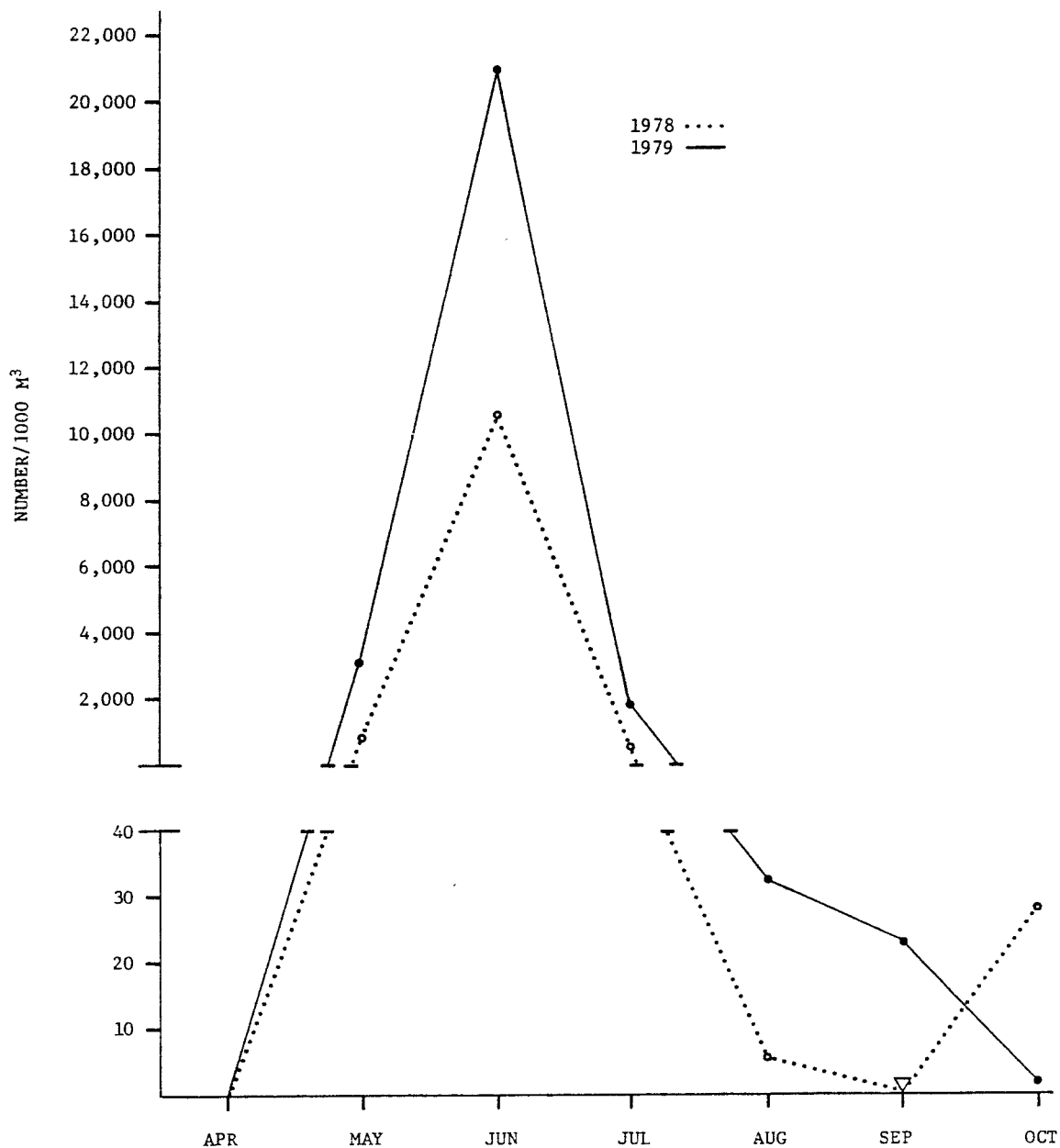


FIGURE 5-11. SUMMARY OF GIZZARD SHAD CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

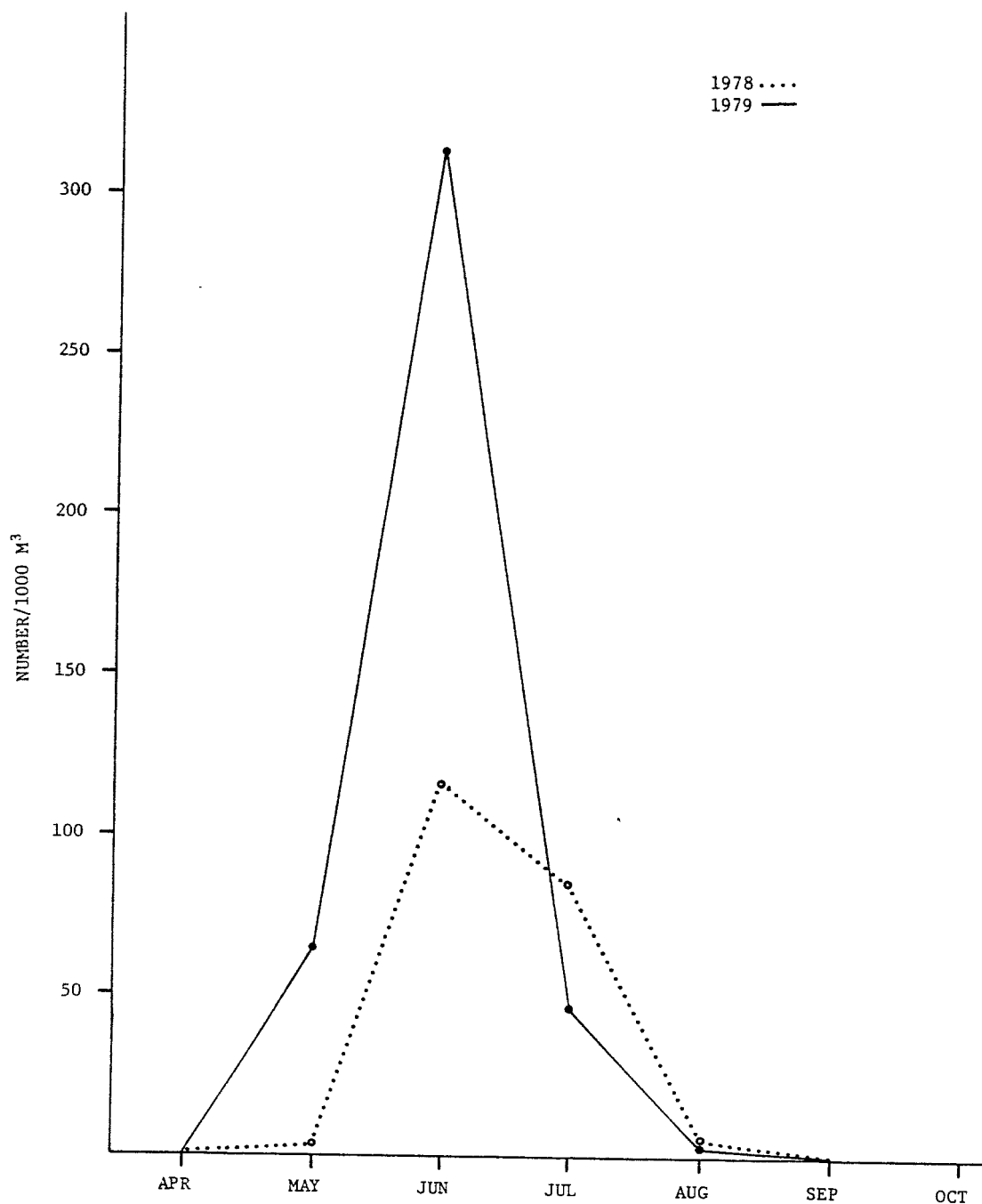


FIGURE 5-12. SUMMARY OF CARP-GOLDFISH CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

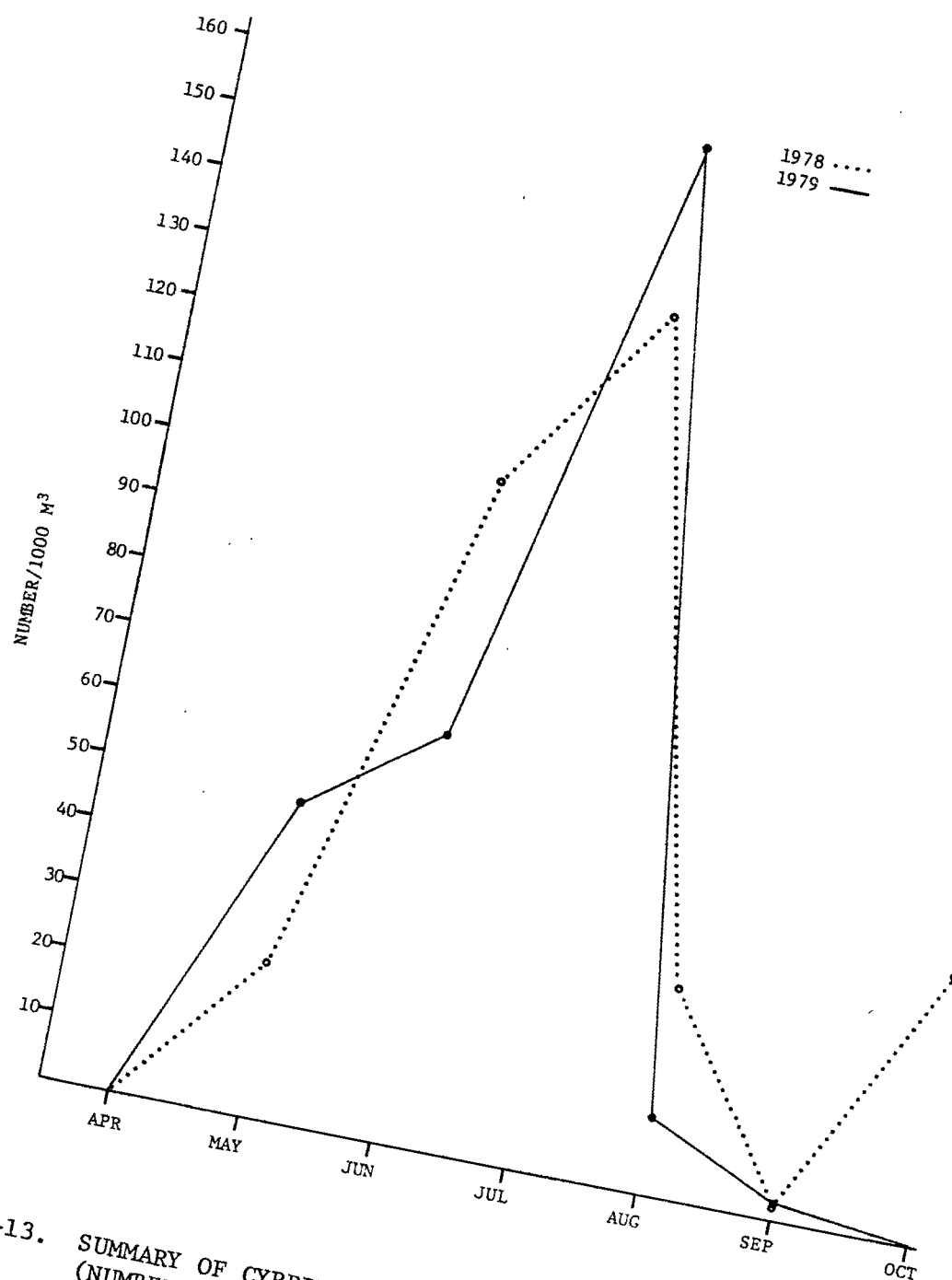


FIGURE 5-13. SUMMARY OF CYPRINIDAE CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

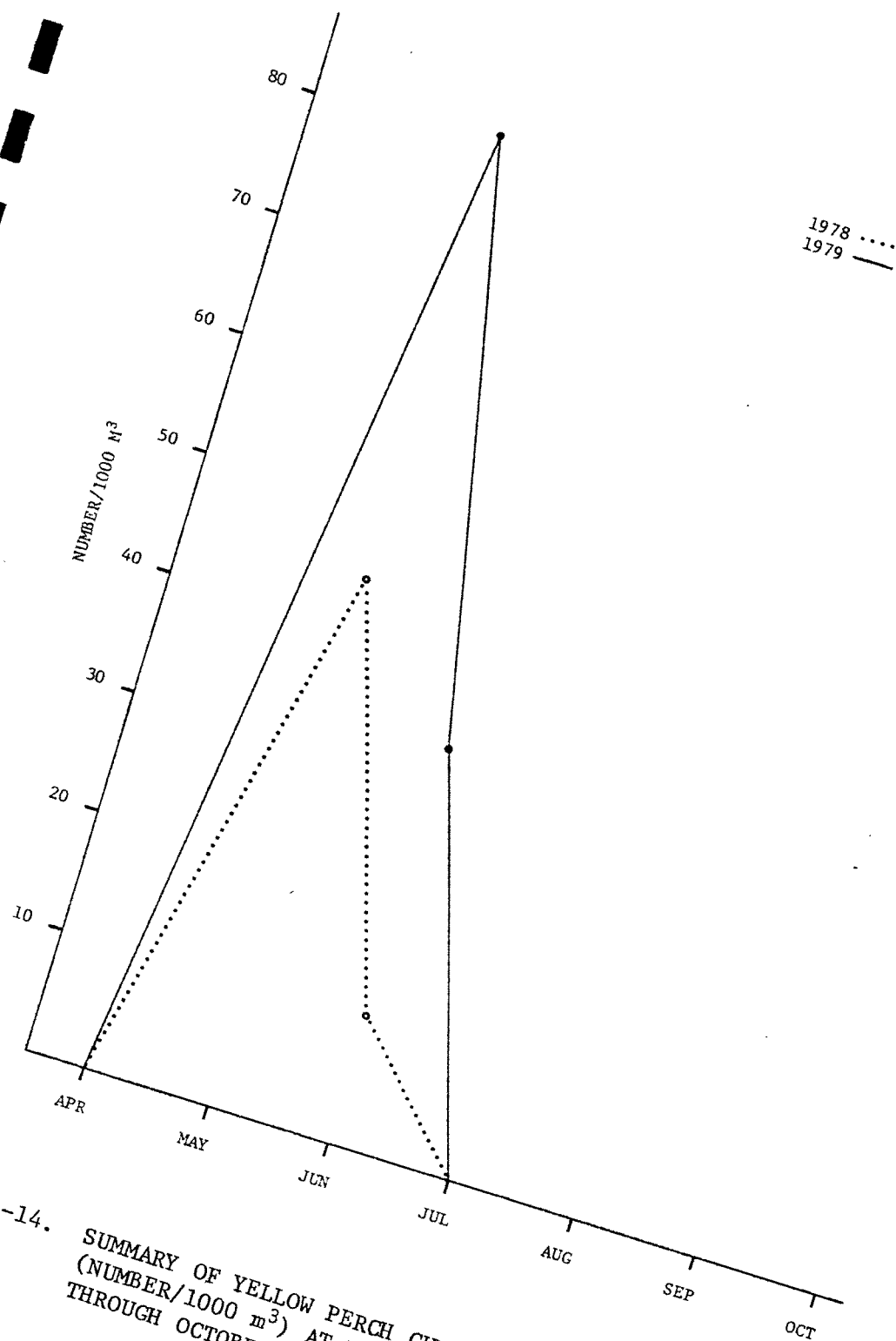


FIGURE 5-14. SUMMARY OF YELLOW PERCH CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

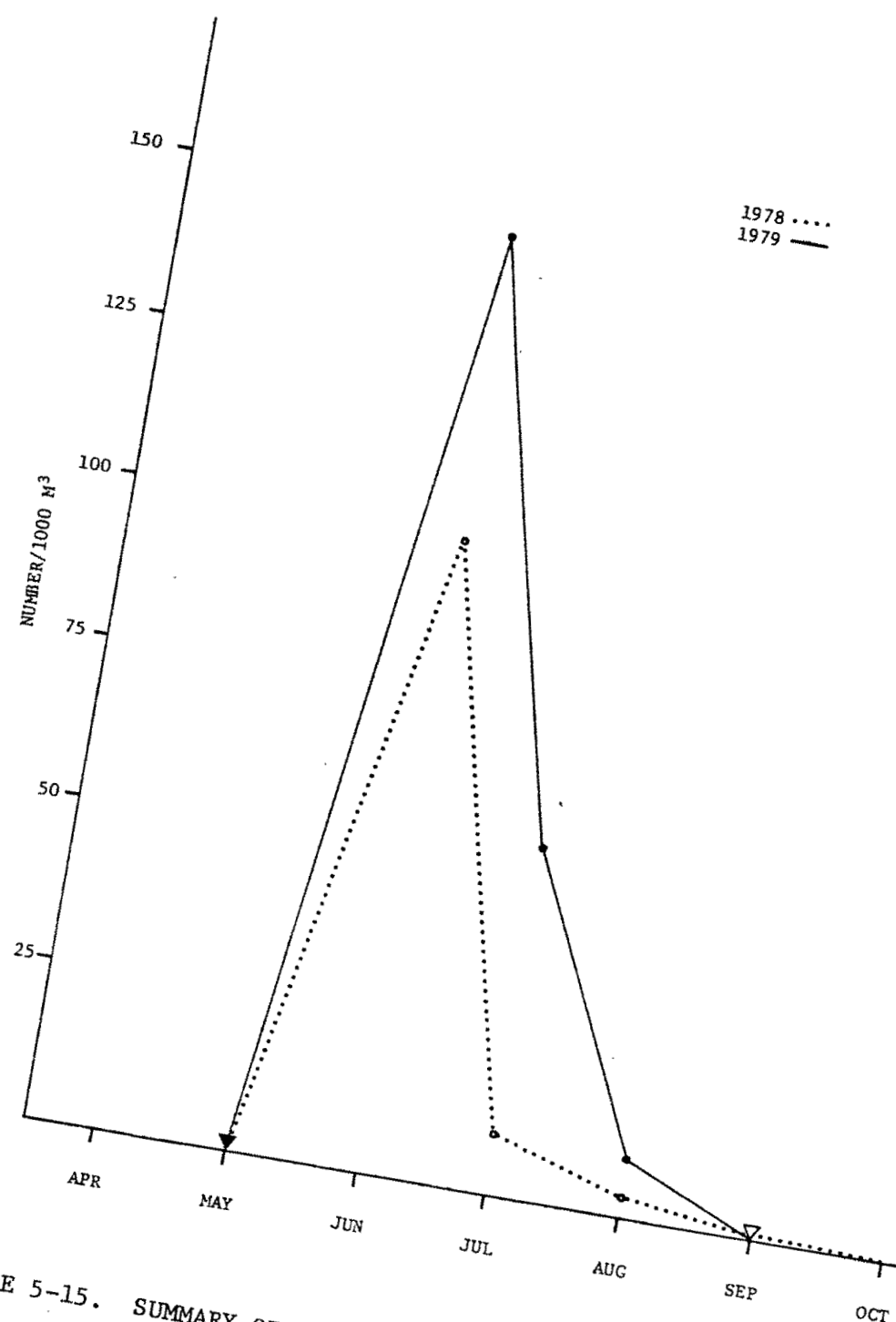


FIGURE 5-15. SUMMARY OF WHITE BASS CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

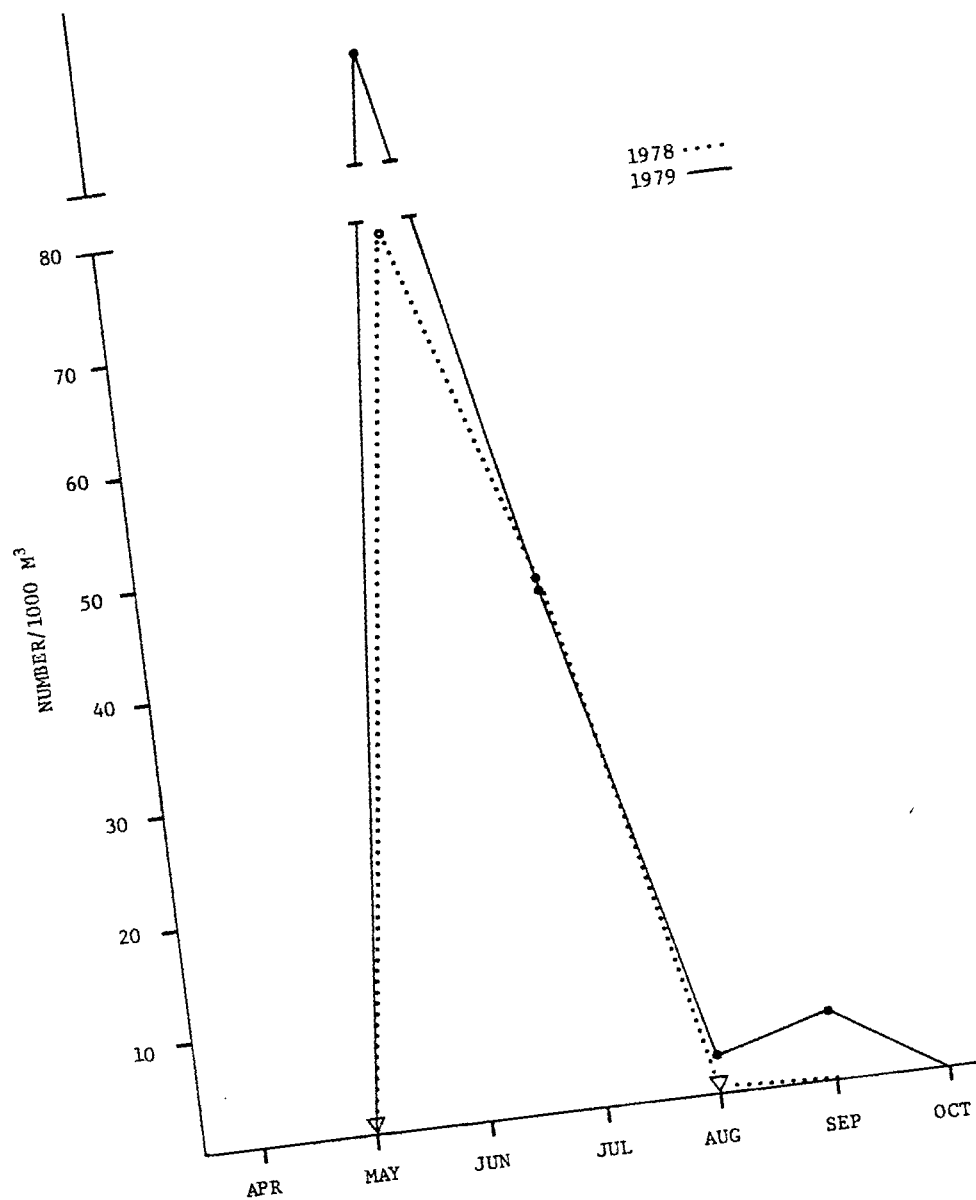


FIGURE 5-16. SUMMARY OF FRESHWATER DRUM CUMULATIVE ENTRAINMENT DENSITY (NUMBER/1000 m³) AT THE J.R. WHITING PLANT FROM APRIL THROUGH OCTOBER 1979.

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